



## Supporting Information

© Wiley-VCH 2014

69451 Weinheim, Germany

### **Regioselective Dihalohydration Reactions of Propargylic Alcohols: Gold-Catalyzed and Non-Catalyzed Reactions\*\***

*Jarryl M. D'Oyley, Abil E. Aliev, and Tom D. Sheppard\**

[anie\\_201405348\\_sm\\_miscellaneous\\_information.pdf](#)

# Table of Contents

General Experimental	2
Preparation of Propargylic alcohols	3
Further Reaction Optimisation Details	7
General Procedure for Dihalohydration Reactions	9
Preparation of Diiodoketoalcohols	9
Preparation of Dichloroketoalcohols	11
Preparation of Homopropargylic alcohols and alkynols	14
Preparation of Dichlorolactols	16
Reductions	17
<i>N</i> -Acylimine Intermediates	19
References	20
NMR Spectra for all novel compounds	21

## **General Experimental**

All reactions were carried out in oven-dried glassware under an argon atmosphere unless otherwise indicated. Diethyl ether, tetrahydrofuran, toluene and dichloromethane were used following purification from an anhydrous engineering zeolite drying apparatus. All other chemicals were used as supplied unless otherwise indicated. Column chromatography was carried out using BDH (40-60 µm) silica gel and analytical thin layer chromatography was carried out using Merck Keiselgel aluminium-backed plates coated with silica gel. Components were visualised using combinations of ultra-violet lights and potassium permanganate. Melting points were determined using a Reichert hot-stage apparatus and are uncorrected. Optical rotations were measured using a Perkin-Elmer 241 or Perkin-Elmer 343 polarimeter (sodium D-line, 529 nm) and  $[\alpha]_D$  values are given in  $10^{-1}$  deg cm<sup>2</sup> g<sup>-1</sup>, concentration (c) in g per 100 mL. Infrared (IR) spectra were recorded on a Perkin-Elmer 1605 Fourier transform spectrometer or a Perkin-Elmer spectrum 100 FT-IR spectrometer as thin films. <sup>1</sup>H NMR spectra were recorded at 500 MHz on a Bruker Avance 500 spectrometer or at 600 MHz on a Bruker Avance 600 spectrometer in the stated solvent using residual protic solvent CHCl<sub>3</sub> ( $\delta$ = 7.26 ppm, s), as the internal standard. Chemical shifts are quoted in ppm using the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; qn, quintet; sx, sextet; m, multiplet; br, broad or a combination of these. The coupling constants (J) are measured in Hertz. <sup>13</sup>C NMR spectra were recorded at 125 MHz on a Bruker Avance 500 spectrometer or at 150 MHz on a Bruker Avance 600 spectrometer in the stated solvent using the central reference of CHCl<sub>3</sub> ( $\delta$ = 77.0 ppm, t) as the internal standard. Chemical shifts are reported to the nearest 0.1 ppm. Mass spectra were obtained using either a VG70-SE or MAT 900XP spectrometer at the Department of Chemistry, University College London.

Compounds 1c, 1m, 5b, 5d and 5g are commercially available. Compounds 1e and 1j were prepared as previously described.<sup>1</sup>

### Propargylic alcohols

**General Procedure A<sup>1</sup>:** *n*-Butyllithium (1.6M in hexanes, 1.2 eq.) was added dropwise to a stirred solution of alkyne (1 eq.) in dry THF (1 mL mmol<sup>-1</sup>) at -78 °C under an argon atmosphere. After 1 h aldehyde or ketone (1 eq.) was added and the resulting solution was stirred for 5 min at 0 °C and 1 h at rt. The reaction was quenched with saturated NH<sub>4</sub>Cl solution and the organic phase extracted with Et<sub>2</sub>O. The combined organic phases were washed with brine, dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified by column chromatography to give the propargylic alcohol.

### **1-(p-Tolyl)hex-1-yn-3-ol (1a)**

Prepared according to General procedure A

Yellow oil, 96%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3331, 2959, 2932, 1509; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.32 (2H, d, *J* = 7.9, 2 × ArH), 7.10 (2H, d, *J* = 7.9, 2 × ArH), 4.60 (1H, t, *J* = 6.6, CHO), 2.34 (3H, s, ArCH<sub>3</sub>), 2.28 (1H, br. s, OH), 1.72 - 1.84 (2H, m, CHCH<sub>2</sub>), 1.54 (2H, sx, *J* = 7.4, CH<sub>2</sub>CH<sub>3</sub>), 0.98 (3H, t, *J* = 7.4, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 138.6, 131.7, 129.2, 119.7, 89.7, 85.0, 62.9, 40.1, 21.6, 18.7, 13.9; HRMS: Found (EI): [M]<sup>+</sup> 188.119621, C<sub>13</sub>H<sub>16</sub>O requires 188.12012;

### **1-(o-Tolyl)hex-1-yn-3-ol (1b)**

Prepared according to General procedure A

Yellow oil, 87%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3323, 2958, 2954, 2872, 1485, 1456; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>) δ 7.40 (1H, d, *J* = 7.7, ArH), 7.17 - 7.23 (2H, m, 2 × ArH), 7.12 (1H, td, *J* = 7.7, 1.9, ArH), 4.65 (1H, t, *J* = 6.6, CHO), 2.43 (3H, s, ArCH<sub>3</sub>), 2.13 (1H, br. s, OH), 1.80 (2H, m, CHCH<sub>2</sub>), 1.57 (2H, sx, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>), 0.99 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>) δ 140.2, 132.1, 129.5, 128.4, 125.6, 122.5, 94.3, 83.7, 63.0, 40.2, 20.7, 18.6, 13.7; HRMS: Found (CI): [M+H]<sup>+</sup> 189.128098, C<sub>13</sub>H<sub>17</sub>O requires 189.12794

### **Ethyl 3-hydroxy-5-(p-tolyl)pent-4-yneoate (1d)**

LiHMDS (1M in THF, 2 eq.) was added dropwise to a stirred solution of EtOAc (1 eq.) in dry THF (1 mL mmol<sup>-1</sup>) at -78 °C under an argon atmosphere. After 1 h 3-(p-tolyl)propiolaldehyde (1 eq.) was added and the resulting solution was stirred for 15 min. The reaction was quenched with saturated NH<sub>4</sub>Cl solution and the organic phase extracted with Et<sub>2</sub>O. The combined organic

phases were washed with brine, dried ( $\text{MgSO}_4$ ) and concentrated under reduced pressure. The residue was purified by column chromatography to give the propargylic alcohol.

Orange oil, 71%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3438, 2982, 1734, 1510, 1213, 1097; <sup>1</sup>H NMR (600MHz,  $\text{CDCl}_3$ )  $\delta$  7.31 (2H, d,  $J = 8.3$ , 2  $\times$  ArH), 7.10 (2H, d,  $J = 8.3$ , 2  $\times$  ArH), 4.98 (1H, br. d,  $J = 5.6$ , OCH), 4.21 (2H, m, OCH<sub>2</sub>), 2.83 (2H, m, CHCH<sub>2</sub>), 2.33 (3H, s, ArCH<sub>3</sub>), 1.28 (3H, t,  $J = 7.2$ , CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz,  $\text{CDCl}_3$ )  $\delta$  171.5, 138.8, 131.8, 129.2, 119.3, 87.5, 85.3, 61.2, 59.4, 42.2, 21.6, 14.3; HRMS: Found (Cl): [M+H]<sup>+</sup> 233.11731,  $\text{C}_{14}\text{H}_{17}\text{O}_3$  requires 233.11777

### (R)-Ethyl 3-hydroxy-5-(p-tolyl)pent-4-yneate, ((R)-1d)<sup>2</sup>

(R,R)-Teth-TsDPEN-RuCl (0.6 mg,  $1.0 \times 10^{-3}$  mmol) and HCO<sub>2</sub>H:Et<sub>3</sub>N 5:2 azeotropic mixture (168 mg) were placed into a flask under a nitrogen atmosphere, and ethyl 3-oxo-5-(p-tolyl)pent-4-yneate (0.2 mmol) in degassed dichloromethane (1 cm<sup>3</sup>) was injected. The mixture was stirred at rt until reaction was complete (TLC) and then the solution was concentrated and the residue purified by column chromatography (EtOAc/petrol) to give the chiral alcohol.

Orange oil, 66%;  $[\alpha]_D^{20} + 8.1$ , (c 1.0,  $\text{CHCl}_3$ ) 94:6 er, (R).

The enantiomeric ratio of the alcohol was obtained by Mosher's esters analysis: A solution of alcohol (1 eq.) and (R) or (S)-MTPA (3 eq.) in  $\text{CH}_2\text{Cl}_2$  (0.2M) was stirred at RT. EDCI.HCl (3 eq.) was added, followed by DMAP (3.3 eq.) and the resulting solution was stirred at RT for 24 h. The mixture was partitioned between water and  $\text{CH}_2\text{Cl}_2$ ; the phases were separated and the organic layer was dried ( $\text{MgSO}_4$ ), filtered and solvent removed under reduced vacuum. The crude product was analysed by <sup>1</sup>H NMR. The enantiomeric ratio was determined from the integration of the peaks of the two diastereoisomers.

The enantiomeric purity was determined by integration of the peaks at 6.19 and 6.12 ppm, which indicated a diastereomeric ratio of 94:6

### 5-Phenyl-1-(p-tolyl)pent-1-yn-3-ol (1f)

Prepared according to General procedure A

Yellow solid, 93%; mp 64 – 65 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3383, 3061, 2923, 2227, 1509; <sup>1</sup>H NMR (600MHz,  $\text{CDCl}_3$ )  $\delta$  7.35 - 7.39 (2H, m, 2  $\times$  ArH), 7.30 - 7.34 (2H, m, 2  $\times$  ArH), 7.25 - 7.29 (2H, m, 2  $\times$  ArH), 7.21 - 7.25 (1H, m, 1  $\times$  ArH), 7.14 (2H, d,  $J = 7.9$ , 2  $\times$  ArH), 4.59 - 4.65 (1H, m, CHOH), 2.89 (2H, t,  $J = 7.5$ , PhCH<sub>2</sub>), 2.37 (3H, s, ArCH<sub>3</sub>), 2.11 - 2.20 (2H, m, CHCH<sub>2</sub>); <sup>13</sup>C NMR (150MHz,  $\text{CDCl}_3$ )  $\delta$  141.5, 138.7, 131.8, 129.2, 128.7, 128.6, 126.1, 119.6, 89.3, 85.5, 62.4, 39.5, 31.7, 21.6; HRMS: Found (Cl): [M]<sup>+</sup> 250.135335,  $\text{C}_{18}\text{H}_{18}\text{O}$  requires 250.13577

### **4-Methyl-1-(p-tolyl)pent-1-yn-3-ol (1g)**

Prepared according to General procedure A

Yellow oil, 76%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3351, 2961, 2872, 2225, 1509; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.33 (2H, d, *J* = 7.9, 2  $\times$  ArH), 7.11 (2H, d, *J* = 7.9, 2  $\times$  ArH), 4.39 (1H, d, *J* = 5.3, CHO), 2.34 (3H, s, ArCH<sub>3</sub>), 2.17 (1H, br. s, OH), 1.97 (1H, sx, *J* = 6.8), 1.08 (3H, d, *J* = 6.8, CHCH<sub>3</sub>CH<sub>3</sub>), 1.05 (3H, d, *J* = 6.8, CHCH<sub>3</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  138.6, 131.7, 129.2, 119.8, 88.3, 85.8, 68.5, 34.8, 21.6, 18.4, 17.7; HRMS: Found (EI): [M-H]<sup>+</sup> 187.112643, C<sub>13</sub>H<sub>15</sub>O requires 187.11229

### **1-(p-Tolyl)oct-1-yn-3-ol (1h)**

Prepared according to General procedure A

Yellow oil, 75%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3337, 2954, 2927, 2859, 1509; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  7.32 (2H, d, *J* = 8.1, 2  $\times$  ArH), 7.11 (2H, d, *J* = 8.1, 2  $\times$  ArH), 4.58 (1H, t, *J* = 6.6, CHO), 2.34 (3H, s, ArCH<sub>3</sub>), 1.75 - 1.82 (2H, m, CHCH<sub>2</sub>), 1.48 - 1.56 (2H, m, CHCH<sub>2</sub>CH<sub>2</sub>), 1.31 - 1.38 (4H, m, CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>), 0.91 (3H, t, *J* = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  138.5, 131.6, 129.1, 119.7, 89.7, 85.0, 63.1, 38.0, 31.6, 25.0, 22.6, 21.5, 14.1; HRMS: Found (EI): [M]<sup>+</sup> 216.151670, C<sub>15</sub>H<sub>20</sub>O requires 216.15142

### **1-Ethoxyoct-1-yn-3-ol (1i)**

Prepared according to General procedure A

Colourless oil, 49%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3379, 2955, 2930, 2859, 2262; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  4.38 (1H, m, CHO), 4.08 (2H, q, *J* = 7.2, OCH<sub>2</sub>CH<sub>3</sub>), 1.74 (1H, br. s, OH), 1.57 - 1.69 (2H, m, CHCH<sub>2</sub>CH<sub>2</sub>), 1.42 (2H, sx, *J* = 7.5, CHCH<sub>2</sub>CH<sub>2</sub>), 1.36 (3H, t, *J* = 7.2, OCH<sub>2</sub>CH<sub>3</sub>), 1.26 - 1.34 (4H, m, CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>), 0.88 (3H, t, *J* = 6.8, CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  93.8, 74.7, 62.6, 39.8, 38.8, 31.6, 25.1, 22.7, 14.5, 14.1; HRMS: Found (CI): [M+H]<sup>+</sup> 171.137987, C<sub>10</sub>H<sub>19</sub>O<sub>2</sub> requires 171.13850

### **3-Ethyl-1-(p-tolyl)pent-1-yn-3-ol (1k)**

Prepared according to General procedure A

Yellow oil, 92%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3384, 2969, 2937, 2226, 1509, 1459; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.33 (2H, d, *J* = 7.9, 2  $\times$  ArH), 7.10 (2H, d, *J* = 7.9, 2  $\times$  ArH), 2.39 (1H, s, OH), 2.34 (3H, s, ArCH<sub>3</sub>), 1.78 (4H, 2  $\times$  dq, *J* = 14.3, 7.5, 2  $\times$  CH<sub>2</sub>), 1.12 (6H, t, *J* = 7.5, 2  $\times$  CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  138.3, 131.7, 129.1, 120.0, 91.2, 84.7, 72.7, 34.6, 21.6, 8.9; HRMS: Found (CI): [M]<sup>+</sup> 202.136131, C<sub>14</sub>H<sub>18</sub>O requires 202.13577

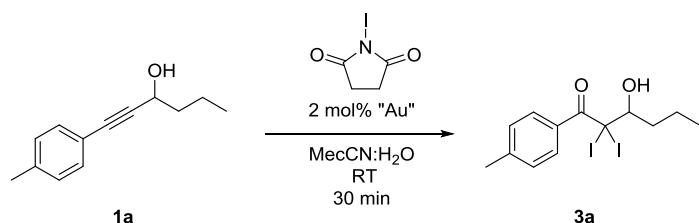
**1,5-Di-p-tolylpenta-1,4-diyn-3-ol (1m)<sup>3</sup>**

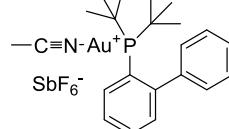
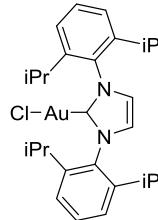
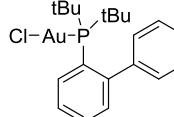
Prepared according to General procedure A

Brown solid, 45%; mp 90 – 92 °C, [82 - 84 °C]<sup>3</sup>;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3326, 2973, 2881, 1379, 1087, 1045;  
<sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>) δ 7.38 (4H, d,  $J$  = 8.1, 4 × ArH), 7.13 (4H, d,  $J$  = 8.3, 4 × ArH), 5.55 - 5.58 (1H, m, CH), 2.35 (6H, s, 2 × CH<sub>3</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>) δ 139.2, 131.9, 129.2, 119.0, 85.5, 84.8, 53.5, 21.7; LRMS: (Cl): 261 ([M+H]<sup>+</sup>, 90), 143 ([M-OH]<sup>+</sup>, 40), 145 (M-tolylacetylene]<sup>+</sup>, 100)

## Further Reaction Optimisation Details

**Table S1** Diiodohydration reaction with different gold catalysts

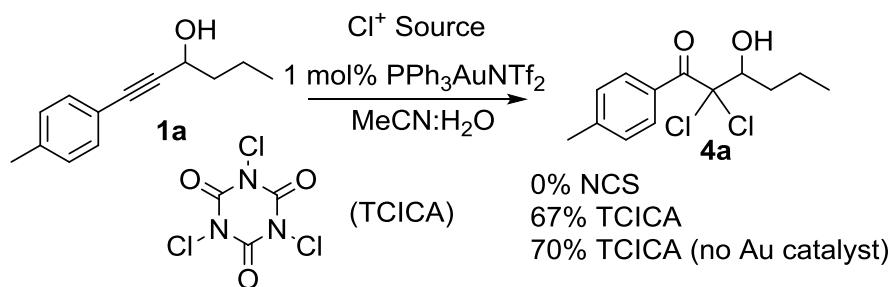


Entry	Catalyst	Yield <b>3a</b> <sup>[a]</sup>
1		72%
2		86%
3	Cl–Au–SMe <sub>2</sub>	86%
4		74%
5	Cl–Au–PPh <sub>3</sub>	86%
6	Tf <sub>2</sub> N–Au–PPh <sub>3</sub>	99% (75% <sup>[b]</sup> )
7	AuCl <sub>3</sub>	60% ( <b>3a</b> ) 16% ( <b>2a</b> )
8	AuBr <sub>3</sub>	99%

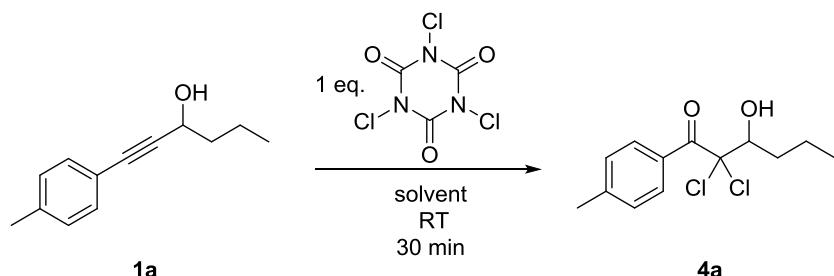
<sup>[a]</sup>Yield calculated by crude NMR with trimethoxybenzene as an internal standard. [b]1 eq of 2,6-di-tert-butylpyridine was added; yield measured after 24 h.

Treatment of an NMR sample of  $\text{PPh}_3\text{AuNTf}_2$  in  $d_3\text{-MeCN}/\text{D}_2\text{O}$  with NIS (1 eq or 10 eq) did not result in significant changes to the  $^1\text{H}$ ,  $^{13}\text{C}$  or  $^{31}\text{P}$  NMR spectra. After several hours a metallic precipitate was formed.

**Dichlorohydration reaction initial screen**



**Table S2 Dichlorohydration reaction in different solvents**



Entry	Solvent	Yield <b>4a</b> <sup>[a]</sup>
1	PhMe:H <sub>2</sub> O 10:1	73%
2	Et <sub>2</sub> O:H <sub>2</sub> O 10:1	23%
3	THF:H <sub>2</sub> O 10:1	40%
4	MeCN:H <sub>2</sub> O 10:1	84%

[a] Yield calculated by crude NMR with trimethoxybenzene as an internal standard

### **General Procedure for Dihalohydration Reactions**

*N*-Iodosuccinimide (248 mg, 1.1 mmol) or trichloroisocyanuric acid (116 mg, 0.5 mmol) was added to a stirring solution of propargylic alcohol (0.5 mmol) and Ph<sub>3</sub>PAuNTf<sub>2</sub> (2 mol%, for iodinations only) in MeCN/H<sub>2</sub>O (2 mL, 10:1). Once the reaction was complete (TLC), the solvent was removed under reduced pressure before the residue was purified by column chromatography (EtOAc/Petrol) to give the dihalohydroxyketone.

### **Diodoketoalcohols**

#### **(Z)-2-Iodo-1-(p-tolyl)hex-2-en-1-one (2a)**

*N*-Iodosuccinimide (124 mg, 0.55 mmol) was added to a stirring solution of propargylic alcohol (0.5 mmol) and Ph<sub>3</sub>PAuNTf<sub>2</sub> (2 mol%) in PhMe (2mL). Once the reaction was complete (TLC), the solvent was removed under reduced before the residue was purified by column chromatography (EtOAc/Petrol) to give the iodoenone.

Yellow oil, 71%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 2960, 2198, 1657, 1603, 1456, 1258, 1179; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.62 (2H, d, *J* = 8.1, 2  $\times$  ArH), 7.24 (2H, d, *J* = 8.1, 2  $\times$  ArH), 6.58 (1H, t, *J* = 7.0, CH), 2.39 - 2.44 (2H, m, CHCH<sub>2</sub>), 2.41 (3H, s, ArCH<sub>3</sub>), 1.55 (2H, sx, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>), 0.99 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  192.0, 153.4, 143.5, 133.1, 130.1, 129.2, 108.4, 39.6, 21.8, 21.3, 14.1; HRMS: Found (EI): [M]<sup>+</sup> 314.015395, C<sub>13</sub>H<sub>15</sub>OI requires 314.01676

#### **3-Hydroxy-2,2-diodo-1-(p-tolyl)hexan-1-one (3a)**

Yellow solid, 71%; mp 88 – 90 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3507, 2955, 1642, 1601, 1379, 1230; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.38 (2H, d, *J* = 8.3, 2  $\times$  ArH), 7.24 (2H, d, *J* = 8.3, 2  $\times$  ArH), 3.68 (1H, br. s, OH), 3.37 (1H, ddd, *J* = 9.4, 4.4, 1.5, CH), 2.45 (3H, s, ArCH<sub>3</sub>), 2.15 (1H, m, CH(OH)CHH), 1.78 (1H, dtd, *J* = 13.9, 9.4, 5.5, CH(OH)CHH), 1.68 - 1.75 (1H, m, CH<sub>3</sub>CHH), 1.51 – 1.59 (1H, m, CH<sub>3</sub>CHH), 1.02 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  191.9, 144.9, 132.0, 130.4, 128.6, 78.7, 39.0, 25.0, 21.9, 19.6, 14.2; HRMS: Found (CI): [M+H]<sup>+</sup> 458.93132, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>I<sub>2</sub> requires 458.93179.

#### **3-Hydroxy-2,2-diodo-1-(o-tolyl)hexan-1-one (3b)**

Brown oil, 71%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3470, 2958, 1662, 1598, 1230; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  8.21 (1H, d, *J* = 7.7, ArH), 7.36 (1H, t, *J* = 7.7, ArH), 7.25 (1H, d, *J* = 7.7, ArH), 7.21 (1H, t, *J* = 7.7, ArH), 3.45 – 3.49 (1H, m, CH), 2.92 (1H, br. s, OH), 2.33 (3H, s, ArCH<sub>3</sub>), 2.11 - 2.21 (1H, m, CH(OH)CHH), 1.64 - 1.75 (2H, m, CH(OH)CHH and CH<sub>3</sub>CHH), 1.48 - 1.58 (1H, m, CH<sub>3</sub>CHH), 1.01 (3H, t, *J* = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  198.1, 137.23, 137.17, 131.1, 130.7, 128.8, 125.1, 78.4, 39.1, 29.3, 20.6, 19.5, 14.0; HRMS: Found (CI): [M+H]<sup>+</sup> 458.93219, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>I<sub>2</sub> requires 458.93179

### **3-Hydroxy-2,2-diodo-1-phenylpropan-1-one (3c)**

Brown oil, 68%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3414, 2915, 1649, 1445, 1229; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  8.48 (2H, d, *J* = 8.5, 2 × ArH), 7.57 (1H, t, *J* = 7.4, ArH), 7.46 (2H, t, *J* = 7.9, 2 × ArH), 4.21 (2H, d, *J* = 7.7, CH<sub>2</sub>), 3.42 (1H, t, *J* = 7.7, OH); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  191.5, 134.0, 131.6, 130.4, 128.0, 76.0, 10.0; HRMS: Found (Cl): [M+H]<sup>+</sup> 402.8692, C<sub>9</sub>H<sub>9</sub>O<sub>2</sub>I<sub>2</sub> requires 486.8684

### **Ethyl 3-hydroxy-4,4-diodo-5-oxo-5-(p-tolyl)pentanoate (3d)**

Brown oil, 78%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3503, 2978, 1723, 1648, 1602, 1372, 1182; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.37 (2 H, d, *J* = 8.5, 2 × ArH), 7.25 (1H, d, *J* = 8.5, 2 × ArH), 4.22 (2H, q, *J* = 7.2, OCH<sub>2</sub>), 4.10 (1H, ddd, *J* = 9.5, 3.7, 1.9, OCH), 3.94 (1H, dd, *J* = 4.1, 1.9, OH), 3.26 (1H, d, *J* = 16.0 OCHCHH), 2.87 (1H, dd, *J* = 16.0, 9.5, OCHCHH), 2.45 (3H, s, ArCH<sub>3</sub>), 1.31 (3H, t, *J* = 7.2, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  191.1, 171.0, 145.1, 131.9, 130.0, 128.7, 75.9, 61.2, 42.7, 21.9, 19.6, 14.3; HRMS: Found (Cl): [M-H]<sup>+</sup> 502.92162, C<sub>14</sub>H<sub>17</sub>O<sub>4</sub>I<sub>2</sub> requires 502.921095

### **Ethyl 3-hydroxy-4,4-diodo-5-oxo-5-(p-tolyl)pentanoate ((R)-3d)**

92%,  $[\alpha]_D^{20}$  – 15.8, (*c* 0.26, CHCl<sub>3</sub>) 94:6 er, (*R*). The enantiomeric ratios of the alcohol was determined by Mosher's esters analysis as described above for **1d**. The enantiomeric purity was determined by integration of the peaks at 8.24 and 8.21 ppm, indicating a diastereomeric ratio of 94:6

### **3-Hydroxy-2,2-diodo-1-(4-methoxyphenyl)hexan-1-one (3e)**

Brown oil, 58%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3253 (OH), 2960 (CH), 1716, 1656, 1595, 1259, 1173; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.49 (2H, d, *J* = 9.0, 2 × ArH), 6.89 (2H, d, *J* = 9.0, 2 × ArH), 3.88 (3H, s, OCH<sub>3</sub>), 3.84 (1H, br. s, OH), 3.34 (1H, d, *J* = 9.4, CH), 2.14 (1H, m, CH(OH)CHH), 1.78 (1H, dtd, *J* = 14.3, 9.4, 4.9, CH(OH)CHH), 1.67 - 1.75 (1H, m, CH<sub>3</sub>CHH), 1.50 – 1.59 (1H, m, CH<sub>3</sub>CHH), 1.01 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  190.7, 163.8, 134.5, 125.4, 113.1, 78.8, 55.7, 39.0, 25.5, 19.7, 14.2; HRMS: Found (Cl): [M+H]<sup>+</sup> 474.925813, C<sub>13</sub>H<sub>17</sub>O<sub>3</sub>I<sub>2</sub> requires 474.92671

### **3-Hydroxy-2,2-diodo-5-phenyl-1-(p-tolyl)pentan-1-one (3f)**

Brown oil, 63%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3504, 2959, 1637, 1601, 1228; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.37 (2H, d, *J* = 8.7, 2 × ArH), 7.27 - 7.34 (4H, m, 4 × ArH), 7.19 - 7.25 (3H, m, 3 × ArH), 3.79 (1H, br. s, OH), 3.37 (1H, dd, *J* = 9.4, 3.0, CH), 3.04 (1H, ddd, *J* = 13.8, 9.4, 4.8, C(OH)HCHH), 2.83 (1H, ddd, *J* = 13.8, 9.4, 7.5, C(OH)HCHH), 2.55 (2H, td, *J* = 11.3, 8.7, C(OH)HCH<sub>2</sub>CHH), 2.45 (3H, s, ArCH<sub>3</sub>), 2.13 (1H, dtd, *J* = 13.8, 9.4, 4.8, C(OH)HCH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  191.7, 145.0, 141.7, 132.0, 130.2, 128.8, 128.64, 128.56, 126.1, 78.1, 38.6, 32.4, 24.3, 21.9; HRMS: Found (Cl): [M+H]<sup>+</sup> 520.94711, C<sub>18</sub>H<sub>19</sub>O<sub>2</sub>I<sub>2</sub> requires 520.94744

### **3-Hydroxy-2,2-diodo-4-methyl-1-(p-tolyl)pentan-1-one (3g)**

Brown oil, 60%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3527, 2961, 2925, 1646, 1603, 1229, 1182; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 8.29 (2H, d,  $J$  = 8.3, 2 × ArH), 7.23 (2H, d,  $J$  = 8.3, 2 × ArH), 3.52 (1H, dd,  $J$  = 5.8, 3.8, CHO), 3.43 (1H, d,  $J$  = 5.8, OH), 2.44 (3H, s, ArCH<sub>3</sub>), 2.26 (1H, sptd,  $J$  = 6.8, 3.8, CH(CH<sub>3</sub>)<sub>2</sub>), 1.18 (3H, d,  $J$  = 6.8, CH(CH<sub>3</sub>)(CH<sub>3</sub>)), 1.08 (3H, d,  $J$  = 6.8, CH(CH<sub>3</sub>)(CH<sub>3</sub>)); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 192.2, 144.5, 131.8, 130.7, 128.8, 81.4, 34.8, 25.4, 23.7, 21.8, 18.6; HRMS: Found (APCI): [M+H]<sup>+</sup> 458.9300, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>I<sub>2</sub> requires 458.9312

### **3-Hydroxy-2,2-diodo-1-(p-tolyl)octan-1-one (3h)**

Brown oil, 55%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3534, 2953, 1645, 1603, 1230, 1183; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 8.38 (2H, d,  $J$  = 8.5, 2 × ArH), 7.24 (2H, d,  $J$  = 8.5, 2 × ArH), 3.69 (1H, br. s, OH), 3.35 (1H, d,  $J$  = 9.4, CH), 2.45 (3H, s, ArCH<sub>3</sub>), 2.14 - 2.22 (1H, m, C(OH)HCHH), 1.78 (1H, dt,  $J$  = 13.9, 9.2, 4.9, C(OH)HCHH), 1.65 - 1.73 (1H, m, C(OH)HCH<sub>2</sub>CHH), 1.49 - 1.57 (1H, m, C(OH)HCH<sub>2</sub>HH), 1.32 - 1.43 (4H, m, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>), 0.92 (3H, t,  $J$ =7.0, CH<sub>3</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 191.9, 144.9, 132.0, 130.4, 128.6, 79.0, 36.9, 31.8, 26.1, 25.6, 22.8, 21.9, 14.2; HRMS: Found (CI): [M+H]<sup>+</sup> 486.96200, C<sub>15</sub>H<sub>21</sub>O<sub>2</sub>I<sub>2</sub> requires 486.96309

### **Ethyl 3-hydroxy-2,2-diodooctanoate (3i)**

Brown oil, 73%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3479, 2927, 1705, 1462, 1239; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 4.33 (2H, q,  $J$  = 7.2, OCH<sub>2</sub>), 3.13 (1H, d,  $J$  = 9.0, CH), 1.96 - 2.05 (1H, m, OH), 1.58 - 1.67 (2H, m, C(OH)HCH<sub>2</sub>), 1.48 (1H, m, C(OH)HCH<sub>2</sub>CHH), 1.35 (3H, t,  $J$  = 7.2, OCH<sub>2</sub>CH<sub>3</sub>), 1.29 - 1.40 (5H, m, C(OH)HCH<sub>2</sub>CHH and CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>), 0.91 (3H, dt,  $J$  = 6.7, CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 169.2, 78.7, 64.0, 36.4, 31.7, 25.9, 22.7, 14.2, 13.6, 12.9; HRMS: Found (CI): [M+H]<sup>+</sup> 440.94238, C<sub>10</sub>H<sub>19</sub>O<sub>3</sub>I<sub>2</sub> requires 440.94236

## **Dichloroketoalcohols**

### **2,2-Dichloro-3-hydroxy-1-(p-tolyl)hexan-1-one (4a)**

White solid, 70%; mp 64 – 65 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3357, 2962, 1676, 1606, 1257, 1187; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 8.20 (2H, d,  $J$  = 8.1, 2 × ArH), 7.27 (2H, d,  $J$  = 8.1, 2 × ArH), 4.39 (1H, d,  $J$  = 9.4, CH), 3.26 (1H, br. s, OH), 2.43 (3H, s, ArCH<sub>3</sub>), 1.90 - 2.00 (1H, m, C(OH)HCHH), 1.67 - 1.79 (2H, m, C(OH)HCHH and C(OH)HCH<sub>2</sub>HH), 1.44 - 1.55 (1H, m, C(OH)HCH<sub>2</sub>HH), 1.01 (3H, t,  $J$  = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 189.9, 145.4, 131.5, 129.1, 129.0, 88.1, 76.7, 32.6, 21.9, 19.4, 14.1; HRMS: Found (APCI): [M+H]<sup>+</sup> 275.0598, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>Cl<sub>2</sub> requires 275.0600.

### **3-Hydroxy-2,2-dichloro-1-(o-tolyl)hexan-1-one (4b)**

Colourless oil, 61%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3444, 2961, 1705, 1238; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.89 (1H, d, *J* = 7.7, ArH), 7.39 (1H, t, *J* = 7.7, ArH), 7.25 (2H, m, 2  $\times$  ArH), 4.47 (1H, m, CH), 2.63 (1H, d, *J* = 6.4, OH), 2.37 (3H, s, ArCH<sub>3</sub>), 1.91 – 1.99 (1H, m, CH(OH)CHH), 1.64 - 1.75 (2H, m, CH(OH)CHH and CH<sub>3</sub>CHH), 1.44 - 1.54 (1H, m, CH<sub>3</sub>CHH), 1.00 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  195.6, 137.9, 135.3, 131.4, 131.2, 127.9, 125.0, 90.3, 76.5, 33.2, 20.5, 19.3, 14.0; HRMS: Found (ES+): [M+Na]<sup>+</sup> 297.0475, C<sub>13</sub>H<sub>16</sub>O<sub>2</sub>Cl<sub>2</sub>Na requires 297.0425.

### **2,2-Dichloro-3-hydroxy-1-phenylpropan-1-one (4c)**

Colourless oil, 71%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3397, 1683, 1596, 1580, 1259; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  8.32 (2H, d, *J* = 8.5, 2  $\times$  ArH), 7.62 (1H, t, *J* = 7.4, ArH), 7.49 (2H, t, *J* = 7.7, 2  $\times$  ArH), 4.27 (2H, d, *J* = 7.7, CH<sub>2</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  189.3, 134.3, 131.3, 131.2, 128.4, 70.7, 63.7; HRMS: Found (ES+): [M+H]<sup>+</sup> 218.9995, C<sub>9</sub>H<sub>9</sub>O<sub>2</sub>Cl<sub>2</sub> requires 218.9980

### **Ethyl 4,4-dichloro-3-hydroxy-5-oxo-5-(p-tolyl)pentanoate (4d)**

Colourless oil, 80%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3496, 2982, 1732, 1680, 1569; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.19 (2H, d, *J* = 8.5, 2  $\times$  ArH), 7.28 (2H, d, *J* = 8.5, 2  $\times$  ArH), 5.02 (1H, dt, *J* = 9.7, 2.5, OCH), 4.22 (2H, q, *J* = 7.2, CH<sub>2</sub>CH<sub>3</sub>), 3.58 (1H, br. s, OH), 3.06 (1H, dd, *J* = 16.0, 2.5, OCHCHH), 2.83 (1H, dd, *J* = 16.0, 9.7, OCHCHH), 2.44 (3H, s, ArCH<sub>3</sub>), 1.30 (3H, t, *J* = 7.2, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  189.0, 171.1, 145.6, 131.5, 129.1, 128.8, 86.5, 73.8, 61.2, 36.8, 21.9, 14.3; HRMS: Found (APCI): [M+H]<sup>+</sup> 319.0496, C<sub>14</sub>H<sub>17</sub>Cl<sub>2</sub>O<sub>4</sub> requires 319.0498

### **Ethyl (*R*)-4,4-dichloro-3-hydroxy-5-oxo-5-(p-tolyl)pentanoate ((*R*)-4d)**

80%,  $[\alpha]_D^{20} - 18.5$  (*c* 1.0, CHCl<sub>3</sub>) 92:8 er, (*R*). The enantiomeric ratio was determined by Mosher's esters analysis as described above for **1d**. The enantiomeric purity was determined by integration of the peaks at 2.92 and 2.81 ppm, indicating a diastereomeric ratio of 92:8

### **2,2-dichloro-3-hydroxy-1-(4-methoxyphenyl)hexan-1-one (4e)**

White solid, 68%; mp 78 – 80 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3516, 2960, 1665, 1596, 1253, 1179; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.32 (2H, d, *J* = 9.0, 2  $\times$  ArH), 6.95 (2H, d, *J* = 9.0, 2  $\times$  ArH), 4.37 (1H, d, *J* = 9.4, CH), 3.90 (3H, s, OCH<sub>3</sub>), 3.34 (1H, br. s, OH), 1.91 – 2.00 (1H, m, CH(OH)CHH), 1.68 - 1.80 (2H, m, 2H, m, C(OH)HCHH and C(OH)HCH<sub>2</sub>HH), 1.44 – 1.54 (1H, m, C(OH)HCH<sub>2</sub>HH), 1.01 (3H, t, *J* = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  188.9, 164.3, 134.0, 124.2, 113.6, 88.0, 76.7, 55.7, 32.5, 19.4, 14.1; HRMS: Found (ES+): [M+H]<sup>+</sup> 291.0579, C<sub>13</sub>H<sub>17</sub>O<sub>3</sub>Cl<sub>2</sub> requires 291.0555.

### **3-Hydroxy-2,2-dichloro-5-phenyl-1-(p-tolyl)pentan-1-one (4f)**

Yellow oil, 79%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3433, 2969, 1675, 1604, 1256, 1187; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.20 (2H, d, *J* = 8.3, 2  $\times$  ArH), 7.19 - 7.36 (7H, m, 7  $\times$  ArH), 4.40 (1H, br. d, *J* = 10.2, CH), 3.40 (1H, d, *J* = 1.9, OH), 3.06 (1H, ddd, *J* = 13.7, 9.6, 4.6, C(OH)HCHH), 2.79 (1H, ddd, *J* = 13.7, 9.1, 7.7, C(OH)HCHH), 2.44 (3H, s, ArCH<sub>3</sub>), 2.34 (1H, ddd, *J* = 14.1, 9.1, 7.7, C(OH)HCH<sub>2</sub>CHH), 2.11 (1H, ddd, *J* = 14.1, 9.6, 4.6, C(OH)HCH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  189.8, 145.5, 141.6, 131.5, 129.2, 129.0, 128.7, 128.6, 128.2, 87.8, 76.1, 32.16, 32.11, 21.9; HRMS: Found (ES+): [M+H]<sup>+</sup> 337.0771, C<sub>18</sub>H<sub>19</sub>O<sub>2</sub>Cl<sub>2</sub> requires 337.0762

### **2,2-Dichloro-3-hydroxy-4-methyl-1-(p-tolyl)pentan-1-one (4g)**

Colourless oil, 60%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3545, 2964, 1674, 1605, 1238, 1186; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.16 (2H, d, *J* = 8.3, 2  $\times$  ArH), 7.27 (2H, d, *J* = 8.3, 2  $\times$  ArH), 4.30 (1H, d, *J* = 3.4, CHO), 3.10 (1H, br. s, OH), 2.43 (3H, s, ArCH<sub>3</sub>), 2.38 (1H, sptd, *J* = 6.8, 3.4, CH(CH<sub>3</sub>)<sub>2</sub>), 1.14 (3H, d, *J* = 6.8, CH(CH<sub>3</sub>)(CH<sub>3</sub>)), 1.12 (3H, d, *J* = 6.8, CH(CH<sub>3</sub>)(CH<sub>3</sub>)); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  190.0, 145.1, 131.3, 129.4, 129.0, 88.8, 79.6, 30.0, 22.8, 21.9, 17.5; HRMS: Found (CI): [M+H]<sup>+</sup> 275.06975, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>Cl<sub>2</sub> requires 275.06056

### **2,2-Dichloro-3-hydroxy-1-(p-tolyl)octan-1-one (4h)**

Colourless oil, 60%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3551, 2957, 2928, 1674, 1605, 1254, 1186; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  8.20 (2H, d, *J* = 8.2, 2  $\times$  ArH), 7.27 (2H, d, *J* = 8.2, 2  $\times$  ArH), 4.37 (1H, dd, *J* = 9.7, 1.5, CH), 3.10 - 3.31 (1H, br. s, OH), 2.43 (3H, s, ArCH<sub>3</sub>), 1.98 (1H, m, C(OH)HCHH), 1.65 - 1.78 (2H, m, C(OH)HCHH and C(OH)HCH<sub>2</sub>HH), 1.42 - 1.51 (1H, m, C(OH)HCH<sub>2</sub>HH), 1.32 - 1.42 (4H, m, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>), 0.92 (3H, t, *J* = 7.1, CH<sub>3</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  189.9, 145.2, 131.4, 129.2, 129.0, 88.3, 76.9, 31.7, 30.5, 25.8, 22.7, 21.8, 14.1; HRMS: Found (ES+): [M+H]<sup>+</sup> 303.0894, C<sub>15</sub>H<sub>21</sub>O<sub>2</sub>Cl<sub>2</sub> requires 303.0919

### **Ethyl 2,2-dichloro-3-hydroxyoctanoate (4i)**

Colourless oil, 50%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3431, 2957, 2931, 1743, 1250, 1022; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  4.35 (2H, q, *J* = 7.2, OCH<sub>2</sub>), 4.17 - 4.23 (1H, m, CH), 2.56 (1H, d, *J* = 6.0, OH), 1.81 - 1.88 (1H, m, C(OH)HCHH), 1.56 - 1.66 (2H, m, C(OH)HCHH and C(OH)HCH<sub>2</sub>CHH), 1.89 - 1.46 (1H, m, C(OH)HCH<sub>2</sub>CHH), 1.27 - 1.38 (4H, m, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>), 1.36 (3H, t, *J* = 7.2, OCH<sub>2</sub>CH<sub>3</sub>), 0.90 (3H, t, *J* = 6.7, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  166.0, 87.2, 77.4, 64.1, 31.6, 31.1, 25.7, 22.6, 14.1, 13.9; HRMS: Found (ES+): [M+H]<sup>+</sup> 257.0708, C<sub>10</sub>H<sub>19</sub>O<sub>3</sub>Cl<sub>2</sub> requires 257.0711

### **Ethyl 2,2-dichloro-3-hydroxy-5-phenylpentanoate (4j)**

Colourless oil, 70%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3473, 2934, 1741, 1454, 1392, 1235; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.29 - 7.33 (2H, m, 2  $\times$  ArH), 7.20 - 7.25 (3H, m, 3  $\times$  ArH), 4.33 (2H, q, *J* = 7.2, OCH<sub>2</sub>), 4.22 (1H, ddd, *J* =

10.2, 6.8, 1.9, OCH), 2.98 (1H, ddd,  $J$  = 14.0, 9.3, 4.8, OCHCHH), 2.72 - 2.78 (2H, m, OCHCHH and OH), 2.16 - 2.22 (1H, m, PhCHH), 1.97 (1H, ddd,  $J$  = 14.0, 9.3, 4.8, PhCHH), 1.34 (3H, t,  $J$  = 7.2, OCH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  166.0, 141.2, 128.7, 128.65, 128.62, 126.3, 86.7, 76.6, 64.2, 32.8, 32.0, 13.9; HRMS: Found (CI): [M+H]<sup>+</sup> 291.055671, C<sub>13</sub>H<sub>17</sub>O<sub>3</sub>Cl<sub>2</sub> requires 291.05547

### **2,2-Dichloro-3-ethyl-3-hydroxy-1-(p-tolyl)pentan-1-one (4k)**

Colourless oil, 85%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3532, 2972, 1671, 1604, 1235, 1187; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.13 (2H, d,  $J$  = 8.3, 2  $\times$  ArH), 7.26 (2H, d,  $J$  = 8.3, 2  $\times$  ArH), 4.05 (1H, br. s., CH), 2.43 (3H, s, ArCH<sub>3</sub>), 2.01 (4H, q,  $J$  = 7.5, 2  $\times$  CH<sub>2</sub>CH<sub>3</sub>), 1.07 (6H, t,  $J$  = 7.5, 2  $\times$  CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  192.4, 144.9, 131.3, 130.5, 128.8, 92.0, 81.4, 29.0, 21.9, 9.22; HRMS: Found (CI): [M+H]<sup>+</sup> 289.075911, C<sub>14</sub>H<sub>19</sub>Cl<sub>2</sub>O<sub>2</sub> requires 289.075911

### **2,2-Dichloro-1-hydroxyhexan-3-one (4l)**

Colourless oil, 20%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3547, 2959, 1675, 1600; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  4.13 (2H, s, OCH<sub>2</sub>), 2.87 - 2.94 (2H, t,  $J$  = 7.3, COCH<sub>2</sub>), 2.74 (1H, br. s, OH), 1.70 (2H, sx,  $J$  = 7.3, CH<sub>2</sub>CH<sub>3</sub>), 0.97 (3H, t,  $J$  = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  199.8, 85.9, 69.3, 37.6, 17.8, 13.5; HRMS: Found (CI): [M+H]<sup>+</sup> 185.0135412, C<sub>6</sub>H<sub>11</sub>Cl<sub>2</sub>O<sub>2</sub> requires 185.01361

### **2,2,4,4-Tetrachloro-3-hydroxy-1,5-di-p-tolylpentane-1,5-dione (4m)**

White solid, 46%; mp 145 -148 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3443, 1679, 1602; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  8.02 (4H, d,  $J$  = 8.3, 4  $\times$  ArH), 7.26 (4H, d,  $J$  = 8.3, 4  $\times$  ArH), 5.99 (1H, d,  $J$  = 9.4, OH), 4.17 (1H, d,  $J$  = 9.4, OCH), 2.42 (6H, s, 2  $\times$  CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  188.9, 144.7, 130.9, 129.6, 129.1, 86.8, 77.7, 21.9; HRMS: Found (APCI): [M+H]<sup>+</sup> 432.9920, C<sub>19</sub>H<sub>17</sub>Cl<sub>4</sub>O<sub>3</sub> requires 432.9926

### **Homopropargylic alcohols and alkynols**

**General Procedure B:** *n*-Butyllithium (1.6M in hexanes, 1.2 eq.) was added dropwise to a stirred solution of alkyne (1 eq.) in dry THF (1 mL mmol<sup>-1</sup>) at -78 °C under an argon atmosphere. After 1 h BF<sub>3</sub>.OEt<sub>2</sub> (2.5 eq.) was added and stirred for 30 min before epoxide (2.5 eq.) was added and the resulting solution was stirred for 5 min at 0 °C and 1 h at rt. The reaction was quenched with saturated NH<sub>4</sub>Cl solution and the organic phase extracted with Et<sub>2</sub>O. The combined organic phases were washed with brine, dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified by column chromatography to give the homopropargylic alcohol.

### **5-(p-Tolyl)pent-4-yn-2-ol (5a)**

Prepared according to General procedure B

Yellow oil, 31%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3353, 2970, 2922, 1509; <sup>1</sup>H NMR (500MHz, CDCl<sub>3</sub>)  $\delta$  7.31 (2H, d, *J* = 8.1, 2 × ArH), 7.10 (2H, d, *J* = 8.1, 2 × ArH), 4.04 (1H, qnd, *J* = 6.4, 5.1, OCH), 2.62 (1H, dd, *J* = 16.8, 5.2, CHCHH), 2.54 (1H, dd, *J* = 16.8, 6.4, CHCHH), 2.34 (3H, s, ArCH<sub>3</sub>), 1.32 (3H, d, *J* = 6.4, CHCH<sub>3</sub>); <sup>13</sup>C NMR (125MHz, CDCl<sub>3</sub>)  $\delta$  138.1, 131.6, 129.1, 120.3, 85.4, 83.3, 66.7, 30.2, 22.5, 21.6; HRMS: Found (Cl): [M+H]<sup>+</sup> 175.112819, C<sub>12</sub>H<sub>15</sub>O requires 175.11229

### **2-Methyl-5-(p-tolyl)pent-4-yn-2-ol (5c)**

Prepared according to General procedure B

Yellow oil, 66%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3393, 2973, 1509, 1376, 1213; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.32 (2H, d, *J* = 8.0, 2 × ArH), 7.10 (2H, d, *J* = 8.0, 2 × ArH), 2.59 (2H, s, CH<sub>2</sub>), 2.34 (3H, s, ArCH<sub>3</sub>), 1.37 (6H, s, CH<sub>2</sub>C(CH<sub>3</sub>)(CH<sub>3</sub>)); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  138.1, 131.6, 129.1, 120.4, 85.6, 83.7, 70.4, 35.2, 28.8, 21.6; HRMS: Found (EI): [M]<sup>+</sup> 188.120324, C<sub>13</sub>H<sub>16</sub>O requires 188.12012

### **5-(p-Tolyl)pent-4-yn-1-ol (5e)<sup>4</sup>**

Pd(PPh<sub>3</sub>)<sub>4</sub> (0.01 eq.) and Cul (0.02 eq.) were added to the solution of iodotoluene (2.0 equiv) and alkynol (1.0 eq.) in triethylamine (10 eq.) and THF (0.5 mL mmol<sup>-1</sup>) under Ar. The reaction mixture was stirred at rt for 12 h. The mixture was filtered and the filtrate was concentrated under reduced pressure. The product was purified by column chromatography to give the alkynol.

Orange solid, 95%; mp 40 – 41 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3324, 2924, 1509, 1045; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.28 (2H, d, *J* = 7.9, 2 × ArH), 7.09 (2H, d, *J* = 7.9, 2 × ArH), 3.82 (2H, t, *J* = 6.5, OCH<sub>2</sub>), 2.53 (2H, t, *J* = 6.5, CCH<sub>2</sub>), 2.33 (3H, s, ArCH<sub>3</sub>), 1.85 (2H, qn, *J* = 6.5, OCH<sub>2</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  137.8, 131.5, 129.1, 120.7, 88.6, 81.3, 62.0, 31.5, 21.5, 16.1; LRMS: (Cl): 175 ([M+H]<sup>+</sup>, 90), 131 ([M-EtOH]<sup>+</sup>, 100)

### **5-(p-Tolyl)pent-4-yne-1,3-diol (5f)**

LiBH<sub>4</sub> (2 eq.) was added to a stirring solution of ester **1d** (150 mg, 0.64 mmol) in Et<sub>2</sub>O (2 mL) at 0 °C. After 2 h the solvent was removed under reduced pressure before the residue was purified by column chromatography (1:1 EtOAc/petrol) to give the diol.

Yellow oil, 102 mg, 0.54 mmol, 84%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3325, 2921, 1509, 1421; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.32 (2H, d, *J* = 7.9, 2 × ArH), 7.11 (2H, d, *J* = 7.9, 2 × ArH), 4.87 (1H, dd, *J* = 6.8, 4.5, OCH), 4.07 (1H, ddd, *J* = 11.0, 7.4, 4.0, OCHH), 3.92 (1H, ddd, *J* = 11.0, 6.8, 4.0, CHH), 2.34 (3H, s, CH<sub>3</sub>), 2.07 - 2.14 (1H, m, OCH<sub>2</sub>CHH), 2.00 - 2.06 (1H, m, OCH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  138.8, 131.7, 129.2, 119.4, 88.7, 85.6, 62.4, 60.7, 39.1, 21.6; HRMS: Found (Cl): [M]<sup>+</sup> 190.098631, C<sub>12</sub>H<sub>14</sub>O<sub>2</sub> requires 190.09938

### **6-(p-tolyl)hex-5-yn-1-ol (5h)<sup>5</sup>**

Pd(PPh<sub>3</sub>)<sub>4</sub> (0.01 eq.) and CuI (0.02 eq.) were added to the solution of iodotoluene (2.0 equiv) and alkynol (1.0 eq.) in triethylamine (10 eq.) and THF (0.5 mL mmol<sup>-1</sup>) under Ar. The reaction mixture was stirred at rt for 12 h. The mixture was filtered and the filtrate was concentrated under reduced pressure. The product was purified by column chromatography to give the alkynol.

Orange oil, 95%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3337, 2937, 1509, 1058; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.28 (2H, d, *J* = 8.1, 2  $\times$  ArH), 7.08 (2H, d, *J* = 8.1, 2  $\times$  ArH), 3.71 (2H, t, *J* = 6.4, OCH<sub>2</sub>), 2.44 (2H, t, *J* = 6.8, CCH<sub>2</sub>), 2.33 (3H, s, CH<sub>3</sub>), 1.72 - 1.77 (2H, m, CCH<sub>2</sub>CH<sub>2</sub>), 1.65 - 1.71 (2H, m, OCH<sub>2</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  137.7, 131.5, 129.1, 120.9, 89.2, 81.1, 62.6, 32.0, 25.2, 21.5, 19.3; HRMS: Found (EI): [M]<sup>+</sup> 188.120621, C<sub>13</sub>H<sub>16</sub>O requires 188.12012

### **Dichlorolactols**

#### **3,3-dichloro-5-methyl-2-(p-tolyl)tetrahydrofuran-2-ol (6a)**

Colourless oil, 79%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3403, 2977, 1513, 1184; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.58 - 7.66 (2H, m, 2  $\times$  ArH), 7.16 - 7.22 (2H, m, 2  $\times$  ArH), 4.60 (1H, dqd, *J* = 9.5, 6.2, 5.8 OCH), 3.00 (1H, dd, *J* = 12.9, 5.8, OCHCHH), 2.86 (1H, dd, *J* = 12.9, 9.5, OCHCHH-major), 2.38 (3H, s, ArCH<sub>3</sub>), 1.42 - 1.48 (3H, m, CHCH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  139.4, 134.9, 128.5, 127.4, 106.1, 91.8, 74.1, 51.8, 22.6, 21.4; HRMS: Found (CI): [M+H]<sup>+</sup> 261.043998, C<sub>12</sub>H<sub>15</sub>Cl<sub>2</sub>O<sub>2</sub> requires 261.04491

#### **3,3-dichloro-2-propyltetrahydrofuran-2-ol (6b)**

Colourless oil, 53%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3421, 2967, 1730, 1046; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  4.09 (1H, td, *J* = 8.8, 2.9, OCHH), 4.03 (1H, br. q, *J* = 8.8, OCHH), 3.01 (1H, dt, *J* = 13.2, 8.8, OCH<sub>2</sub>CHH), 2.75 (1H, ddd, *J* = 13.2, 7.3, 2.9, OCH<sub>2</sub>CHH), 1.53 - 1.67 (4H, m, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>), 0.99 (3H, t, *J* = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  106.6, 91.6, 64.4, 43.9, 36.2, 16.6, 14.5; HRMS: Found (CI): [M-H<sub>2</sub>O]<sup>+</sup> 181.017931, C<sub>7</sub>H<sub>11</sub>Cl<sub>2</sub>O requires 181.01870

#### **3,3-Dichloro-5,5-dimethyl-2-(p-tolyl)tetrahydrofuran-2-ol (6c)**

White solid, 84%; mp 77 – 79 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3420, 2988, 1440; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.63 (2H, d, *J* = 8.3, 2  $\times$  ArH), 7.19 (2H, d, *J* = 8.3, 2  $\times$  ArH), 3.10 (1H, d, *J* = 13.6, COCHH), 3.03 (1H, s, OH), 2.93 (1H, d, *J* = 13.6, COCHH), 2.38 (3H, s, ArCH<sub>3</sub>), 1.56 (3H, s, CCH<sub>3</sub>CH<sub>3</sub>), 1.54 (3H, s, CCH<sub>3</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  139.3, 135.2, 128.5, 127.3, 106.8, 92.0, 80.8, 56.4, 32.2, 28.6, 21.4; HRMS: Found (CI): [M-H]<sup>+</sup> 275.059913, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>Cl<sub>2</sub> requires 275.06056

#### **2-(Dichloromethyl)tetrahydrofuran-2-ol (6d)**

White solid, 99%; mp 66 – 68 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3422, 3010, 1208, 1005; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  5.73 (1H, s, CHCl<sub>2</sub>), 4.16 - 4.22 (1H, m, OCHH), 4.02 (1H, m, OCHH), 2.88 - 3.03 (1H, m, OH), 2.14 -

2.25 (3H, m, OCH<sub>2</sub>CH<sub>2</sub>, OCH<sub>2</sub>CH<sub>2</sub>CHH), 1.99 - 2.06 (1H, m, OCH<sub>2</sub>CH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 106.2, 76.3, 70.4, 34.9, 25.2; HRMS: Found (Cl): [M+H]<sup>+</sup> 170.99651, C<sub>5</sub>H<sub>9</sub>Cl<sub>2</sub>O<sub>2</sub> requires 170.99796

### 3,3-Dichloro-2-(p-tolyl)tetrahydro-2H-pyran-2-ol (6e)

White solid, 73%; mp 97 – 99 °C; ν<sub>max</sub> (film/cm<sup>-1</sup>) 3411, 2971, 1617, 1388, 1074; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.66 (2H, d, J = 8.1, 2 × ArH), 7.19 (2H, d, J = 8.1, 2 × ArH), 4.23 (1H, ddd, J = 13.6, 11.4, 3.0, OCHH), 3.86 (1 H, dd, J = 11.4, 5.5, OCHH), 2.95 (1H, td, J = 13.6, 4.3, OCH<sub>2</sub>CHH), 2.85 (1H, s, OH), 2.55 (1H, d, J = 13.6, OCH<sub>2</sub>CHH), 2.30 - 2.39 (4H, m, ArCH<sub>3</sub>, OCH<sub>2</sub>CH<sub>2</sub>CHH), 1.63 - 1.69 (1H, m, OCH<sub>2</sub>CH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 139.2, 136.5, 128.6, 128.0, 98.8, 91.0, 60.3, 40.4, 23.9, 21.4; HRMS: Found (Cl): [M+H]<sup>+</sup> 261.044010, C<sub>12</sub>H<sub>15</sub>Cl<sub>2</sub>O<sub>2</sub> requires 261.04491

### 3,3-Dichloro-2-(p-tolyl)tetrahydro-2H-pyran-2,4-diol (6f)

White solid, 53%; mp 122 - 126 °C; ν<sub>max</sub> (film/cm<sup>-1</sup>) 3533, 3391, 3297, 2953, 1461, 1435; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.67 (2H, d, J = 8.3, 2 × ArH), 7.21 (2H, d, J = 8.3, 2 × ArH), 4.53 - 4.59 (1H, m, OCH), 4.20 - 4.28 (1H, m, OCHH), 3.89 - 3.95 (1H, m, OCHH), 2.38 (3H, s, CH<sub>3</sub>), 2.13 - 2.22 (1H, m, OCH<sub>2</sub>CHH), 1.97 - 2.02 (1H, m, OCH<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 139.5, 136.0, 128.5, 128.2, 100.5, 96.2, 73.1, 58.9, 31.6, 21.4; HRMS: Found (APCI): [M+H]<sup>+</sup> 277.0393, C<sub>12</sub>H<sub>15</sub>Cl<sub>2</sub>O<sub>3</sub> requires 277.0393

### 2-(Dichloromethyl)tetrahydro-2H-pyran-2-ol (6g)

Colourless oil, 65%; ν<sub>max</sub> (film/cm<sup>-1</sup>) 3432, 2847, 2881, 1727, 1441; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 5.57 (1H, s, CHCl<sub>2</sub>), 3.93 – 3.97 (1H, m, OCHH), 3.79 – 3.92 (1H, m, OCHH), 2.78 (1H, d, J = 2.7, OH), 1.95 (1H, dt, J=13.3, 3.3, (C)CHH), 1.82 - 1.89 (1H, m, OCH<sub>2</sub>CH<sub>2</sub>CHH), 1.72 - 1.79 (1H, m, OCH<sub>2</sub>CH<sub>2</sub>CHH), 1.64 (1 H, ddd, J = 13.3, 4.8, 2.6, (C)CHH), 1.53 - 1.62 (2H, m, OCH<sub>2</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 96.0, 78.2, 62.7, 30.2, 24.7, 19.0; HRMS: Found (ES-): [M-H]<sup>+</sup> 182.9928, C<sub>6</sub>H<sub>9</sub>O<sub>2</sub>Cl<sub>2</sub> requires 182.9980;

### 2,2-Dichloro-6-hydroxy-1-(p-tolyl)hexan-1-one (6h)

Colourless oil, 72%; ν<sub>max</sub> (film/cm<sup>-1</sup>) 3345, 2941, 2873, 1685, 1606, 1253; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 8.19 (2H, d, J=8.3, 2 × ArH), 7.26 (2H, d, J = 8.3, 2 × ArH), 3.72 (2H, t, J = 6.4, OCH<sub>2</sub>), 2.50 - 2.55 (2H, m, Cl<sub>2</sub>CCH<sub>2</sub>), 2.43 (3H, s, CH<sub>3</sub>), 1.76 - 1.83 (2H, m, Cl<sub>2</sub>CCH<sub>2</sub>), 1.67 – 1.72 (2H, m, CH<sub>2</sub>OCH<sub>2</sub>CH<sub>2</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 188.2, 144.7, 131.3, 129.2, 128.9, 87.4, 62.6, 44.2, 32.1, 21.9, 21.4; HRMS: Found (Cl): [M-H]<sup>+</sup> 275.060120, C<sub>13</sub>H<sub>17</sub>O<sub>2</sub>Cl<sub>2</sub> requires 275.06056

### Reductions

**General Procedure C:** NaBH<sub>4</sub> (1.2 eq.) was added to a stirring solution of ketone in MeOH (0.5 mL) at 0 °C. Once the reaction is complete, the reaction was quenched with saturated NH<sub>4</sub>Cl solution and the organic phase extracted with EtOAc. The combined organic phases were dried

(MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified by column chromatography to give the diol.

### **2,2-Dichloro-1-phenylpropane-1,3-diol (7c)**

Prepared according to General procedure C

White solid, 93%; mp 104 – 105 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3326, 3203, 1452, 1110; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.52 - 7.57 (2H, m, 2 × ArH), 7.36 - 7.41 (3H, m, 3 × ArH), 5.24 (1H, s, CHPh), 4.11 (1H, d,  $J$  = 12.4, CHH), 3.89 (1H, d,  $J$  = 12.4, CHH), 3.01 (1H, br. s, OH), 2.57 (1H, br. s, OH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  136.6, 129.2, 128.6, 128.1, 95.4, 78.6, 70.3; HRMS: Found (APCI): [M+NH<sub>4</sub>]<sup>+</sup> 238.0392, C<sub>9</sub>H<sub>14</sub>Cl<sub>2</sub>NO<sub>2</sub> requires 238.0396

### **(1S,3S)-2,2-Dichloro-1-(4-methoxyphenyl)hexane-1,3-diol (*anti*-7e)**

A solution of ketone (1 eq.) in MeCN (0.5mL) was added dropwise to a stirring solution of tetramethylammonium triacetoxyborohydride (8 eq.) in anhydrous MeCN (1.5 mL) and glacial acetic acid (1.5 mL) at -40 °C. After 2 h, CH<sub>2</sub>Cl<sub>2</sub> was added and this solution was washed with saturated NaHCO<sub>3</sub> then the aqueous phase was extracted with CH<sub>2</sub>Cl<sub>2</sub>. The combined organic phases were dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The residue was purified by column chromatography to give the *anti* diol as a 9:1 mixture of diastereomers.

Colourless oil, 71%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3410, 2960, 1611, 1513, 1247; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.47 (2H, d,  $J$  = 8.9, 2 × ArH), 6.91 (2H, d,  $J$  = 8.9, 2 × ArH), 5.25 (1H, s, ArCOH), 4.12 (1H, d,  $J$  = 9.8, CHOCH<sub>2</sub>), 3.83 (3H, s, ArOCH<sub>3</sub>), 2.01 - 2.08 (1H, m, CHOCHH), 1.63 - 1.71 (2H, m, CHOCHH and CH<sub>3</sub>CHH), 1.43 – 1.47 (1H, m, CH<sub>3</sub>CHH), 0.99 (3H, t,  $J$  = 7.2, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  160.0, 130.3, 129.3, 97.9, 78.5, 77.3, 55.4, 34.3, 19.5, 14.0; HRMS: Found (Cl): [M+H]<sup>+</sup> 293.071013, C<sub>13</sub>H<sub>19</sub>O<sub>3</sub>Cl<sub>2</sub> requires 293.7112

### **2,2-Dichloro-3-ethyl-1-(p-tolyl)pentane-1,3-diol (7k)**

Prepared according to General procedure C

White solid, 87%, mp 68 – 70 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3335, 2971, 2943, 1458, 1410; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>)  $\delta$  7.48 (2H, d,  $J$  = 8.1, 2 × ArH), 7.17 (2H, d,  $J$  = 8.1, 2 × ArH), 5.33 (1H, s, ArCH), 2.37 (3H, s, ArCH<sub>3</sub>), 2.02 - 2.19 (4H, m, 2 × CH<sub>2</sub>CH<sub>3</sub>), 1.16 (3H, t,  $J$  = 7.5, CH<sub>2</sub>CH<sub>3</sub>), 1.03 (3H, t,  $J$  = 7.5, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>)  $\delta$  138.6, 134.9, 129.9, 128.2, 100.7, 83.4, 79.5, 28.4, 27.2, 21.4, 9.8, 8.6; HRMS: Found (Cl): [M+H]<sup>+</sup> 291.091218, C<sub>14</sub>H<sub>21</sub>Cl<sub>2</sub>O<sub>2</sub> requires 291.09186

### **2,2-Dichloro-1-(p-tolyl)pentane-1,5-diol (8)**

Prepared according to General procedure C

White solid, 99%; mp 74 – 77 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 3341, 3178, 2966, 1445, 1452, 1048; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.40 (2H, d,  $J$  = 8.1, 2 × ArH), 7.17 (2H, d,  $J$  = 8.1, 2 × ArH), 5.00 (1H, s, CH), 3.68 (2H, t,  $J$  = 6.0, CH<sub>2</sub>OH), 2.36 (3H, s, CH<sub>3</sub>), 2.25 (1H, ddd,  $J$  = 15.6, 7.9, 6.2, C(Cl)<sub>2</sub>CHH), 2.17 (1H, ddd,  $J$  = 15.6, 7.9, 6.2, C(Cl)<sub>2</sub>CHH), 2.00 (2H, dt,  $J$  = 14.3, 6.4, CH<sub>2</sub>CH<sub>2</sub>OH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 138.9, 133.7, 128.74, 128.73, 98.6, 81.9, 62.2, 39.2, 28.2, 21.4; HRMS: Found (Cl): [M]<sup>+</sup> 262.051223, C<sub>12</sub>H<sub>16</sub>O<sub>2</sub>Cl<sub>2</sub> requires 262.05274

### **3,3-Dichloro-2-(p-tolyl)tetrahydro-2H-pyran (9)**

BF<sub>3</sub>OEt<sub>2</sub> (3 eq.) was added to stirring solution of HSiEt<sub>3</sub> (2 eq.) and lactol (1 eq.) in CH<sub>2</sub>Cl<sub>2</sub> (0.5 mL) at -78 °C and then warmed to rt over 15 mins. The solvent was then removed under reduced pressure and the residue was purified by column chromatography to give the tetrahydropyran.

White solid, 80%; mp 78 – 79 °C;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 2974, 1515, 1439, 1185; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.42 (2H, d,  $J$  = 8.3, 2 × ArH), 7.17 (2H, d,  $J$  = 8.3, 2 × ArH), 4.54 (1H, s, OCH), 4.21 (1H, dddd,  $J$  = 11.8, 4.9, 1.6, 1.5, OCHH), 3.65 (1H, ddd,  $J$  = 12.1, 11.8, 2.3, OCHH), 2.82 (1H, dddd,  $J$  = 13.8, 4.2, 2.3, 2.1, OCH<sub>2</sub>CHH), 2.49 (1H, td,  $J$  = 13.2, 4.2, OCH<sub>2</sub>CHH), 2.36 (3H, s, ArCH<sub>3</sub>), 2.31 - 2.34 (1H, m, C(Cl)<sub>2</sub>CHH), 1.67 – 1.71 (1H, m, C(Cl)<sub>2</sub>CHH); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 138.5, 132.9, 129.2, 128.2, 89.7, 87.1, 69.0, 45.5, 24.7, 21.4; HRMS: Found (EI): [M]<sup>+</sup> 244.042276, C<sub>12</sub>H<sub>14</sub>OCl<sub>2</sub> requires 244.04217

## N-Acylimine Intermediates

### **N-((1Z,2Z)-2-Iodo-1-(p-tolyl)hex-2-en-1-ylidene)acetamide (10)**

N-iodosuccinimide (248 mg, 1.1 mmol) was added to a stirring solution of propargylic alcohol (0.5 mmol) in MeCN (2 mL) and Ph<sub>3</sub>PAuNTf<sub>2</sub> (2 mol%). Once reaction was complete (TLC), the solvent was removed under reduced before the residue was purified by column chromatography (EtOAc/Petrol) to give the imine.

Orange oil, 10%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 2960, 2931, 1701, 1619, 1605, 1458, 1206, 1179; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.47 (2H, d,  $J$  = 8.1, 2 × ArH), 7.21 (2H, d,  $J$  = 8.1, 2 × ArH), 6.12 (1H, t,  $J$  = 7.0, CH), 2.40 (3H, s, ArCH<sub>3</sub>), 2.34 (2H, q,  $J$  = 7.0, CHCH<sub>2</sub>), 2.09 (3H, s, COCH<sub>3</sub>), 1.49 - 1.54 (2H, m, CH<sub>2</sub>CH<sub>3</sub>), 0.97 (3H, t,  $J$  = 7.3, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 185.0, 162.3, 149.5, 141.8, 131.3, 129.3, 128.9, 99.5, 39.1, 25.1, 21.6, 21.4, 13.9; HRMS: Found (Cl): [M+H]<sup>+</sup> 356.049974, C<sub>15</sub>H<sub>19</sub>INO requires 356.05058

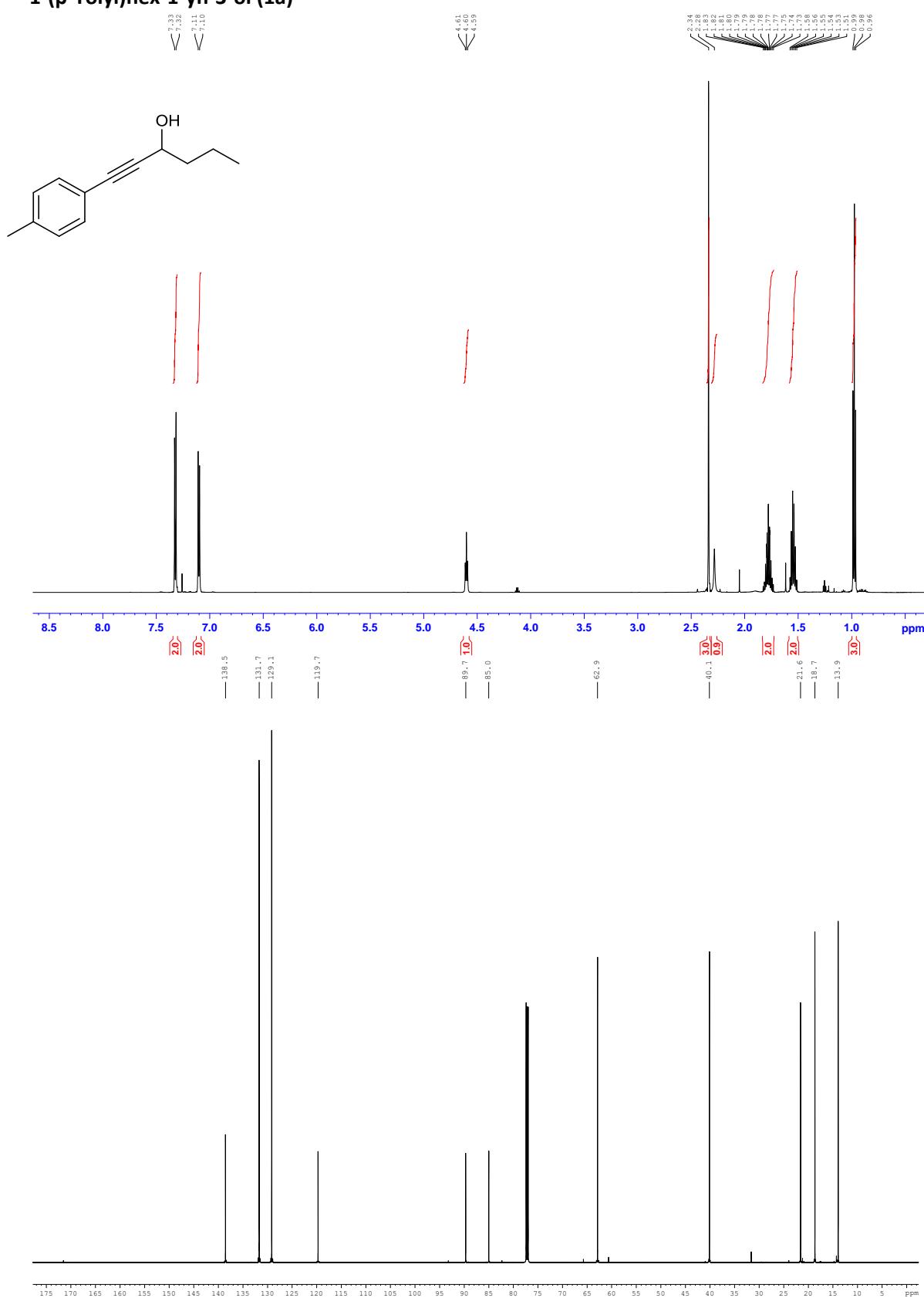
### **(E)-N-Acetyl-2,2-dichloro-3-hydroxy-5-phenylpentanimide (11)**

Colourless oil, 26%;  $\nu_{\text{max}}$  (film/cm<sup>-1</sup>) 1754, 1620, 1370, 1215; <sup>1</sup>H NMR (600MHz, CDCl<sub>3</sub>) δ 7.27 - 7.32 (2H, m, 2 × ArH), 7.18 - 7.23 (3H, m, 3 × ArH), 5.76 (1H, dd,  $J$  = 9.4, 2.4, OCH), 4.65 (2H, m, OCH<sub>2</sub>), 2.69 (2H, t,  $J$  = 8.1, PhCH<sub>2</sub>), 2.10 - 2.22 (2H, m, OCHCH<sub>2</sub>), 2.13 (3H, s, COCH<sub>3</sub>), 1.45 (3H, t,  $J$  = 7.1, CH<sub>2</sub>CH<sub>3</sub>); <sup>13</sup>C NMR (150MHz, CDCl<sub>3</sub>) δ 170.1, 165.3, 140.8, 128.6, 128.5, 126.3, 88.0, 76.3, 72.3, 33.0, 32.1, 20.9, 15.4; HRMS: Found (Cl): [M+H]<sup>+</sup> 332.082067, C<sub>15</sub>H<sub>20</sub>NO<sub>3</sub>Cl<sub>2</sub> requires 332.08202

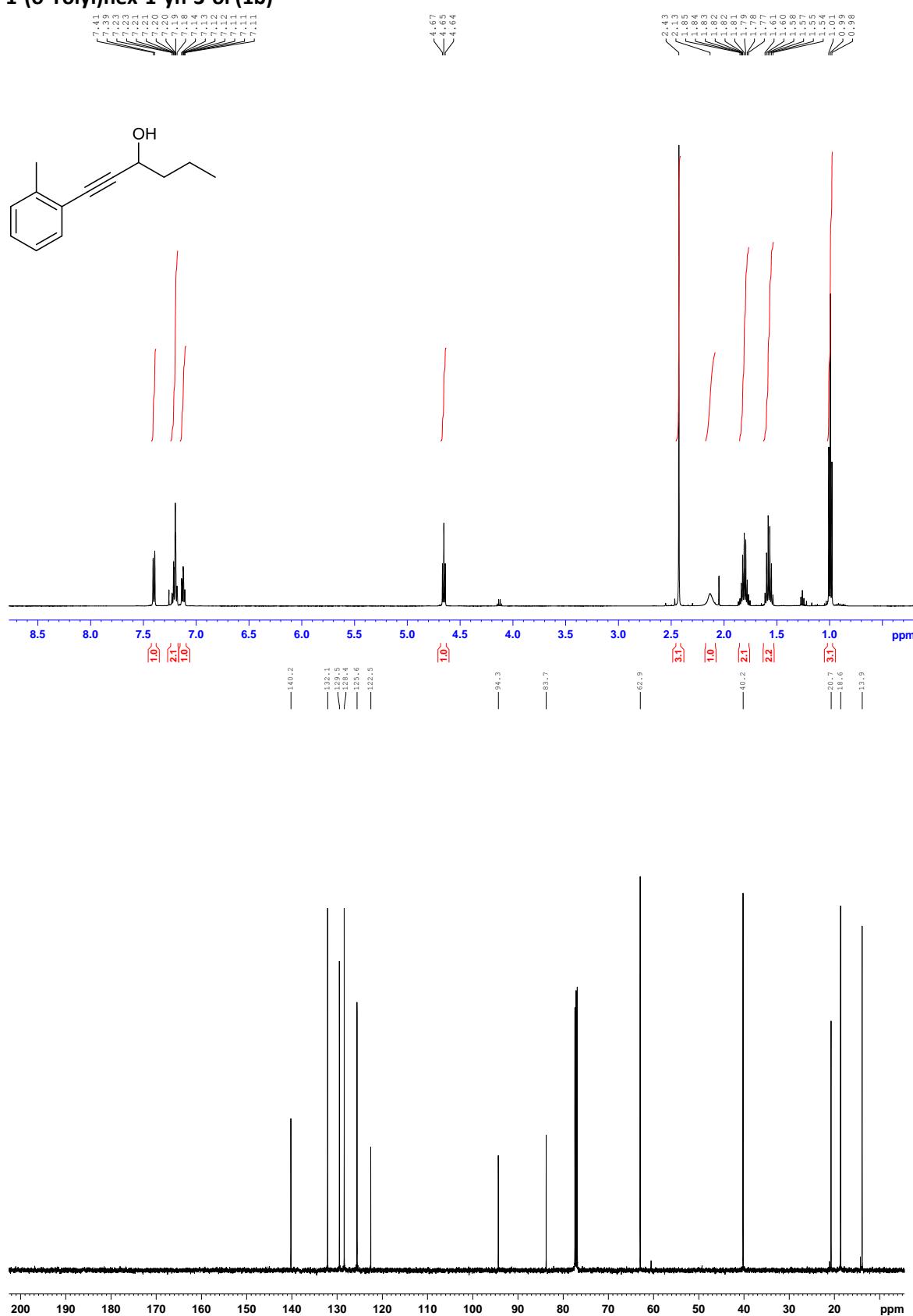
## **References**

- (1) Pennell, M. N.; Turner, P. G.; Sheppard, T. D. *Chem. Eur. J.* **2012**, *18*, 4748–4758.
- (2) Fang, Z.; Wills, M. *J. Org. Chem.* **2013**, *78*, 8594–8605.
- (3) Dermenci, A.; Whittaker, R. E.; Dong, G. *Org. Lett.* **2013**, *15*, 2242–2245.
- (4) Legault, M. C. B.; McKay, C. S.; Moran, J.; Lafreniere, M. A.; Pezacki, J. P. *Tet. Lett.* **2012**, *53*, 5663–5666.
- (5) Mino, T.; Shirae, Y.; Saito, T.; Sakamoto, M.; Fujita, T. *J. Org. Chem.* **2006**, *71*, 9499–9502.

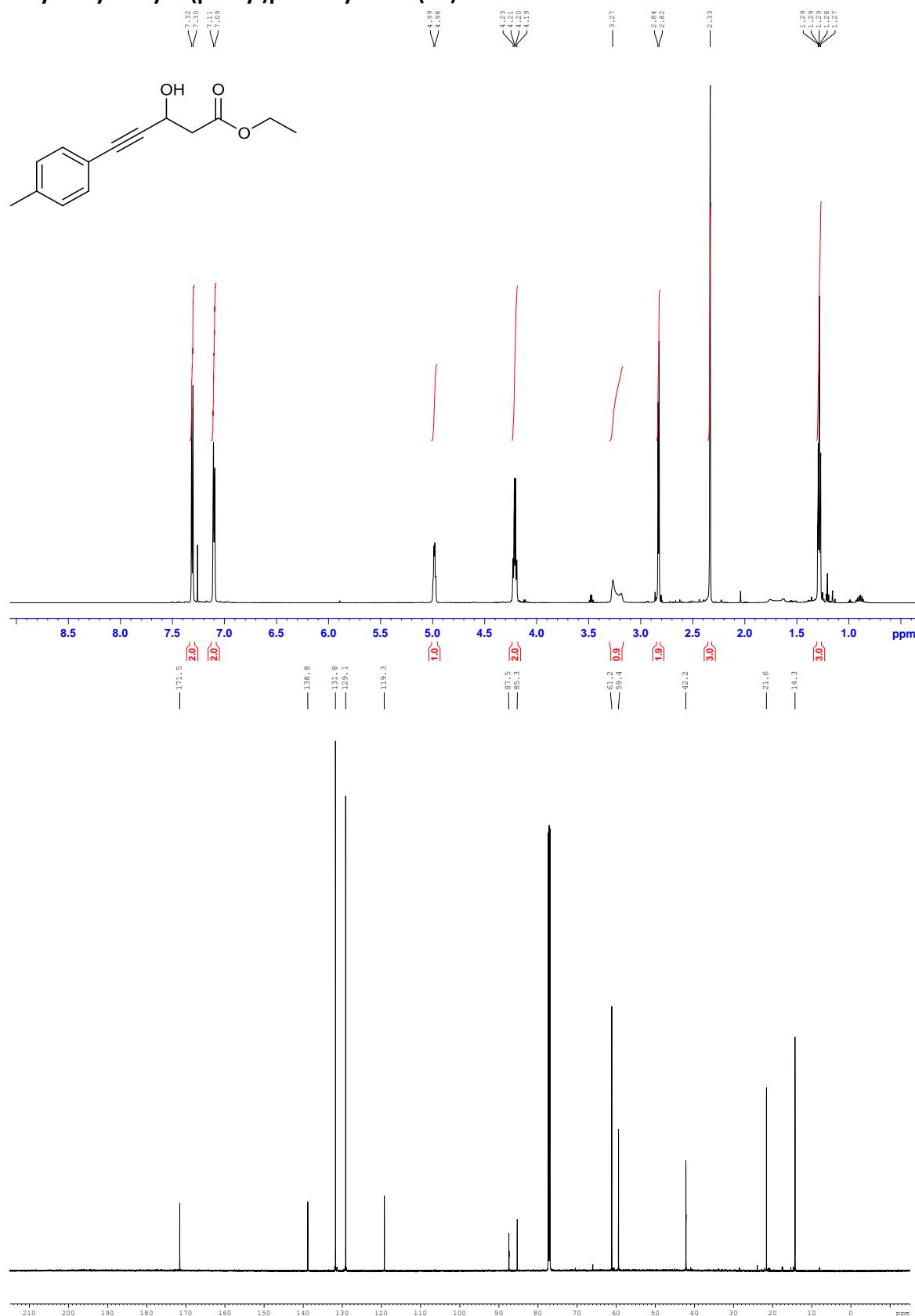
**1-(p-Tolyl)hex-1-yn-3-ol (1a)**



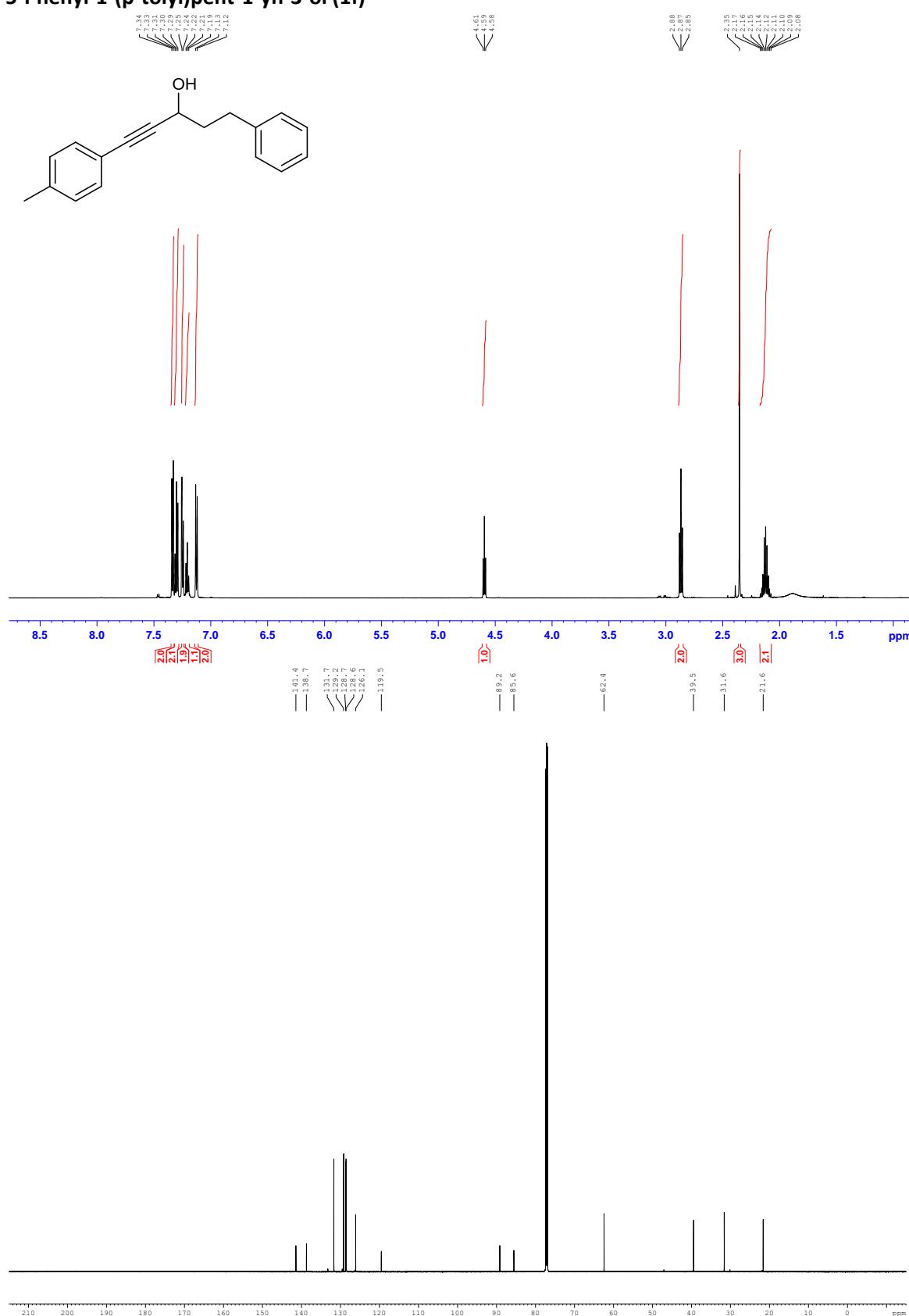
**1-(o-Tolyl)hex-1-yn-3-ol (1b)**



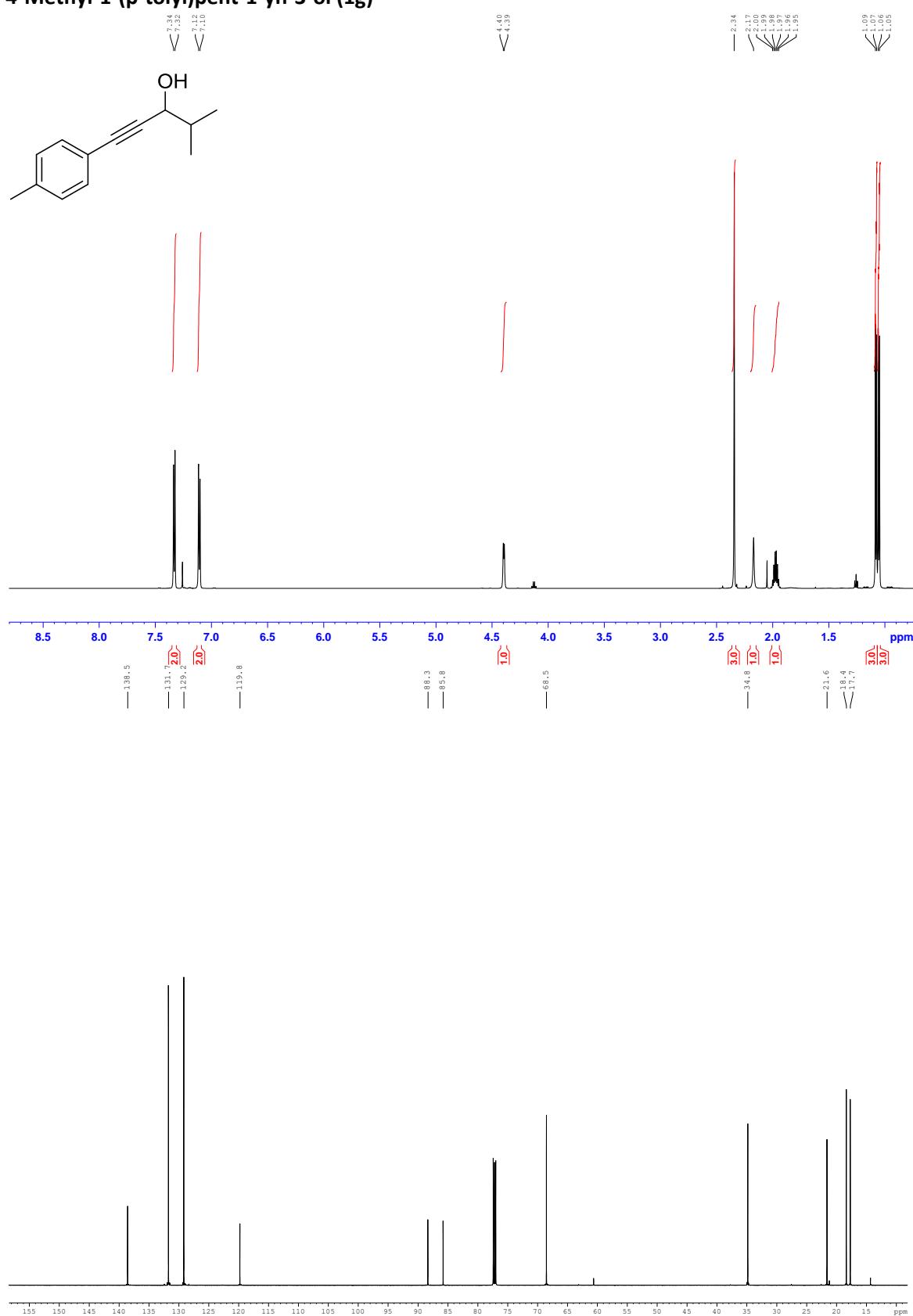
### Ethyl 3-hydroxy-5-(p-tolyl)pent-4-yneate (1d)



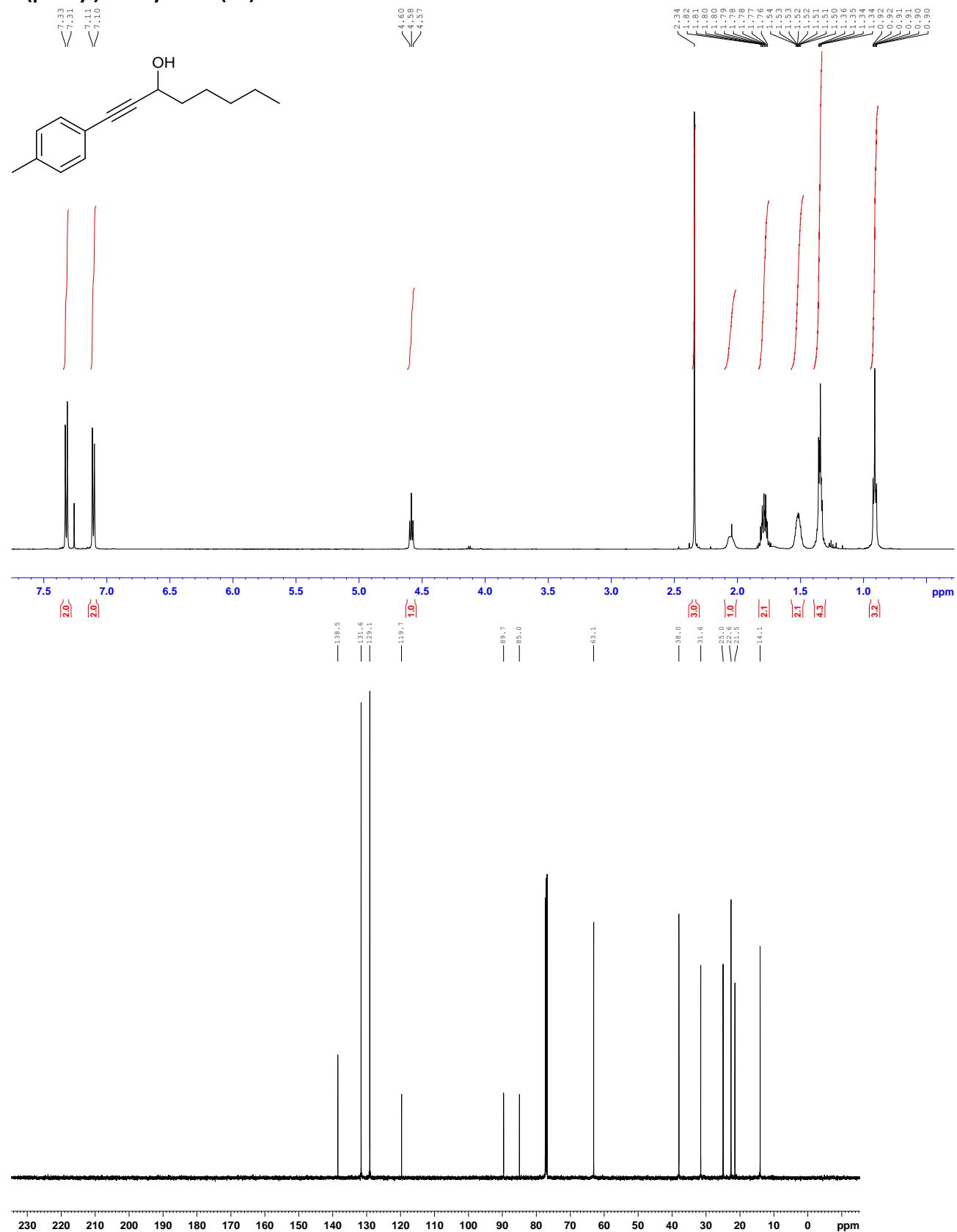
**5-Phenyl-1-(p-tolyl)pent-1-yn-3-ol (1f)**



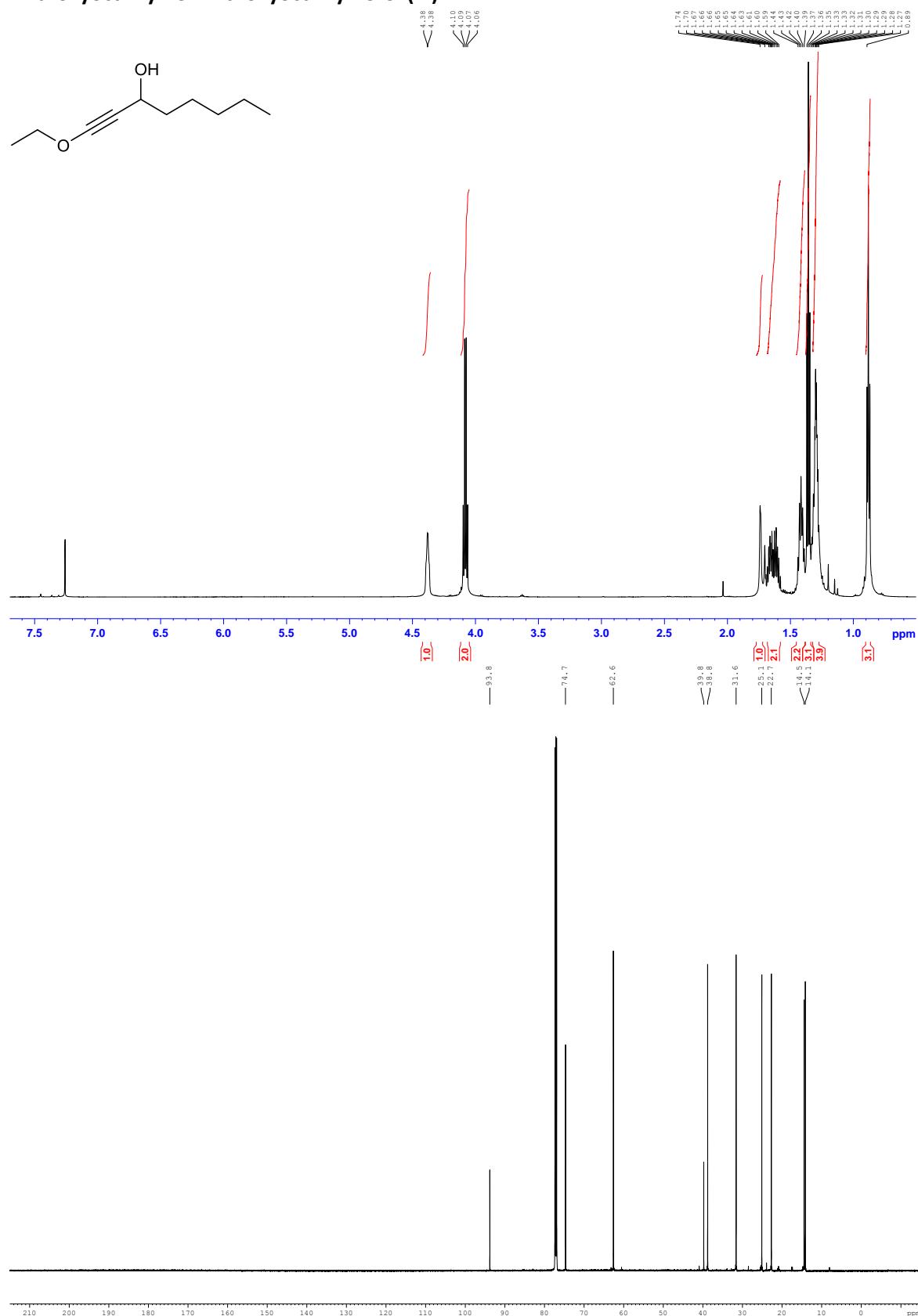
**4-Methyl-1-(p-tolyl)pent-1-yn-3-ol (1g)**



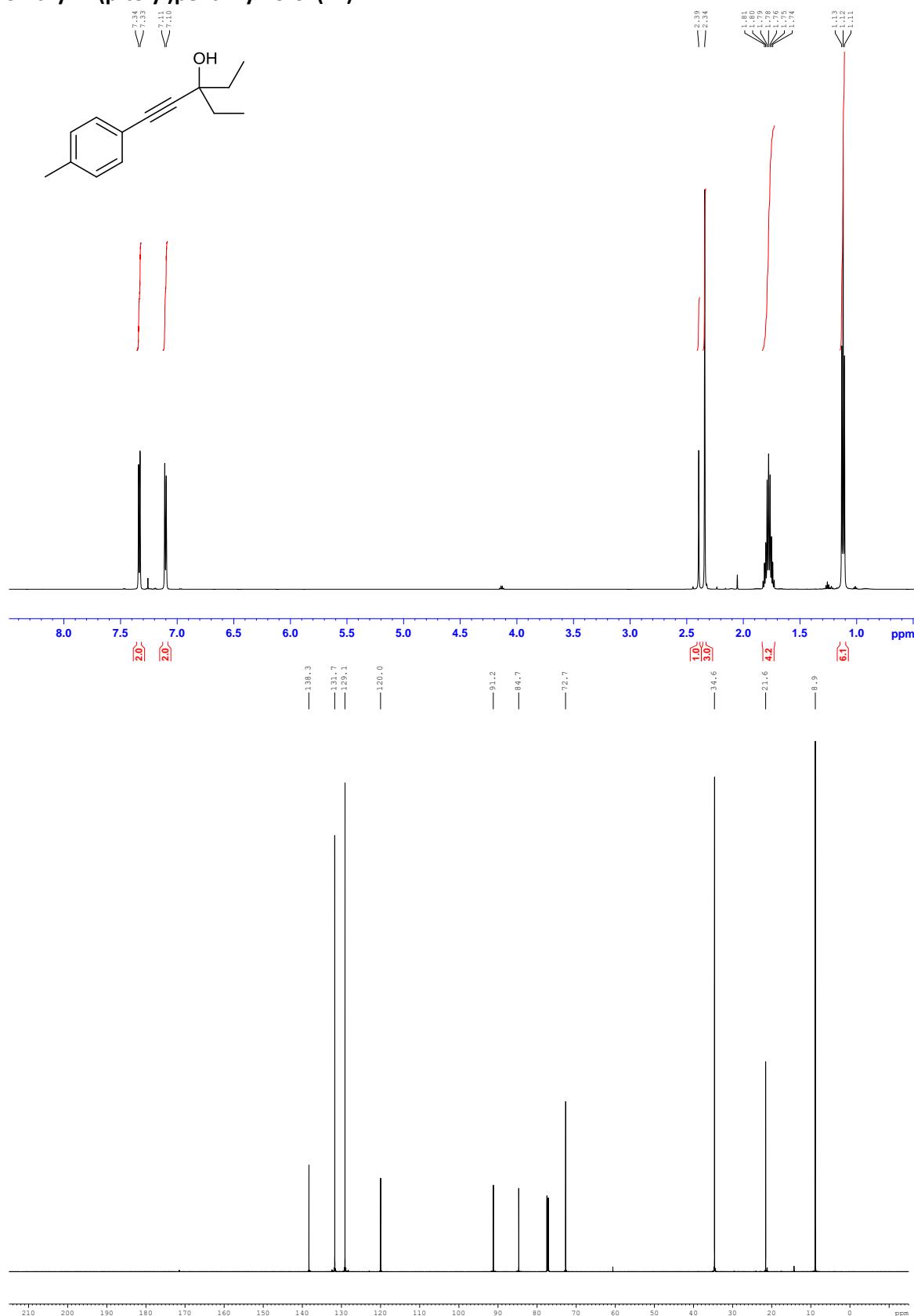
### 1-(*p*-Tolyl)oct-1-yn-3-ol (**1h**)



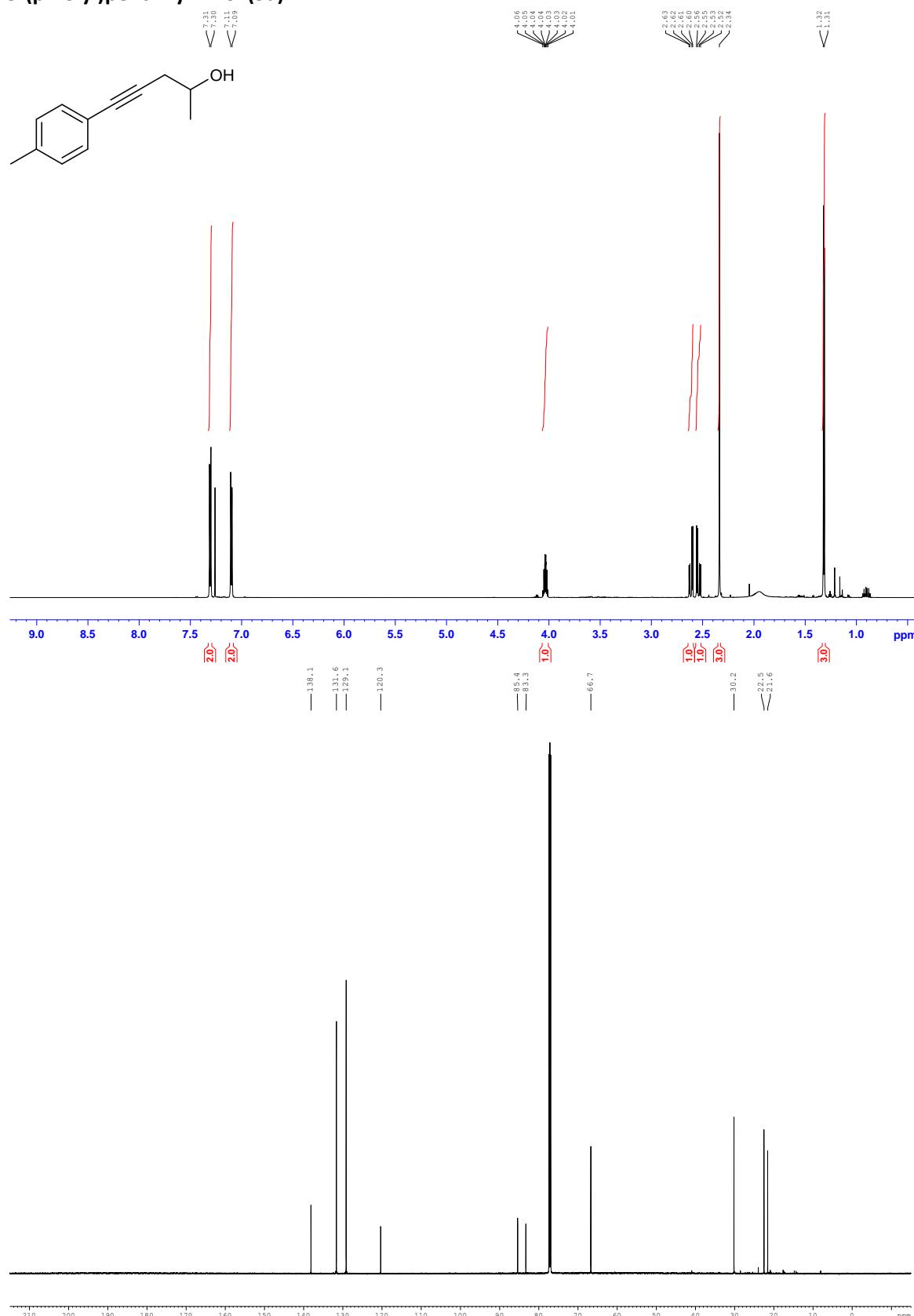
**1-Ethoxyoct-1-yn-3-1-Ethoxyoct-1-yn-3-ol (1i)**



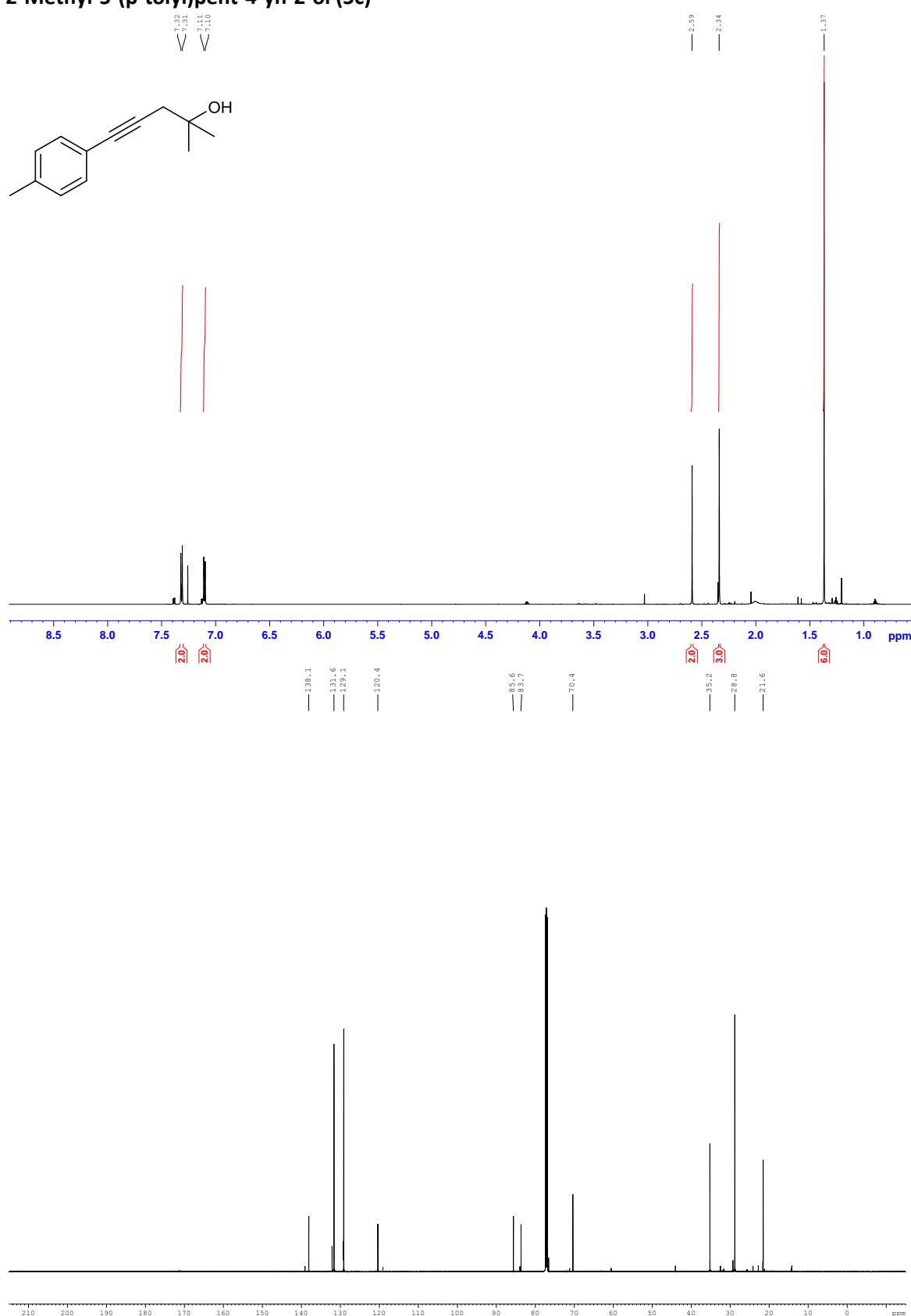
**3-Ethyl-1-(p-tolyl)pent-1-yn-3-ol (1k)**



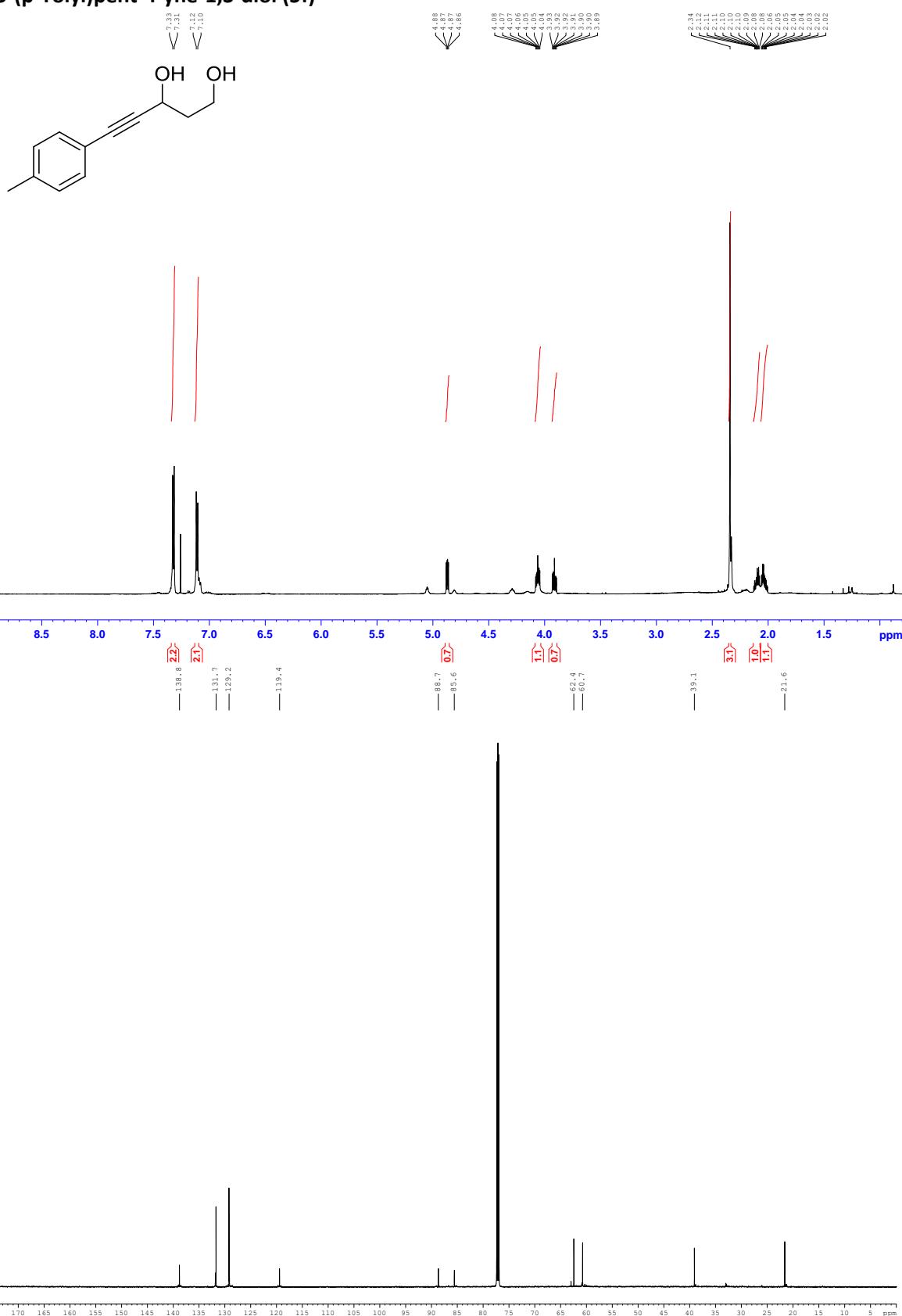
**5-(p-Tolyl)pent-4-yn-2-ol (5a)**



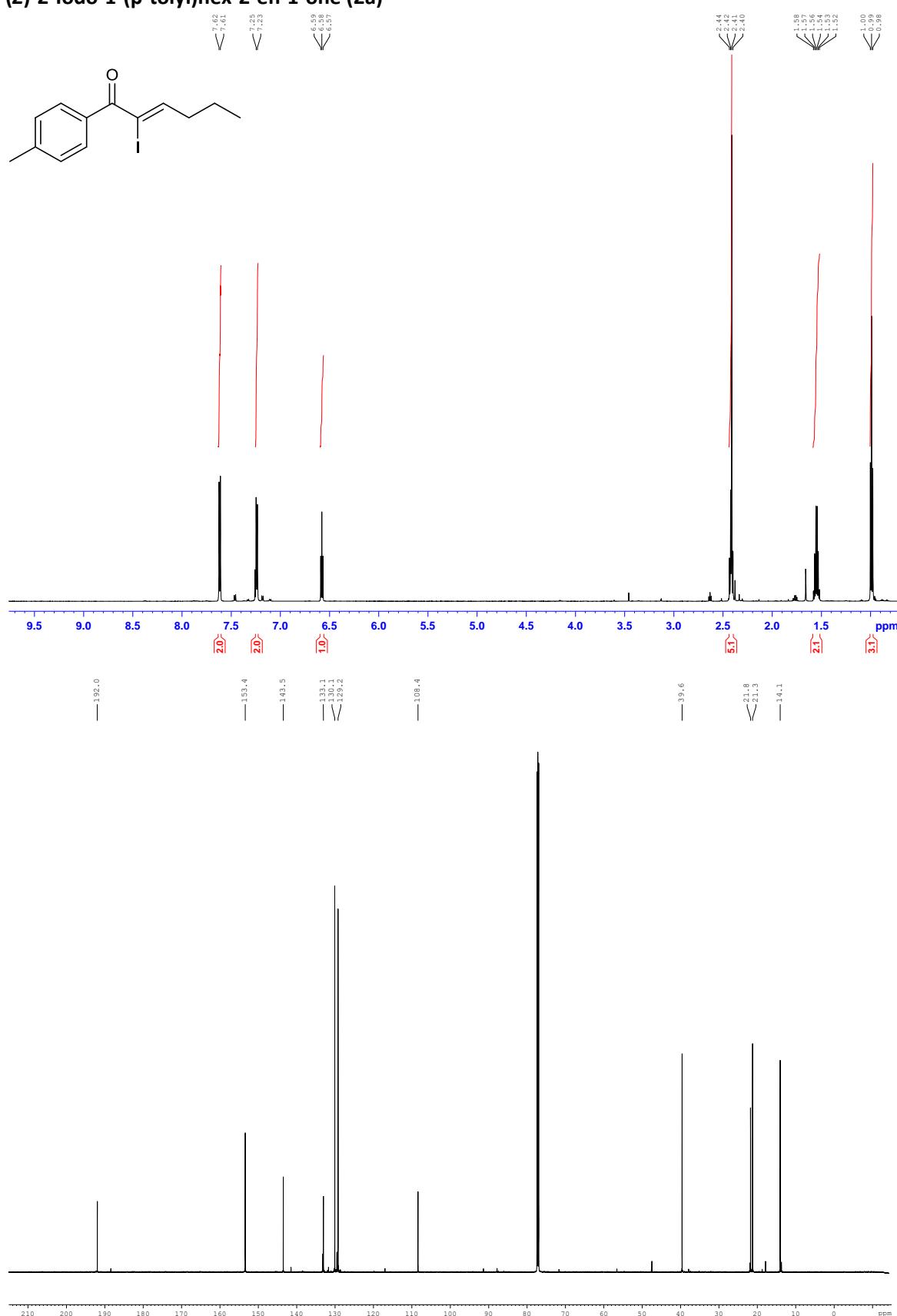
**2-Methyl-5-(p-tolyl)pent-4-yn-2-ol (5c)**



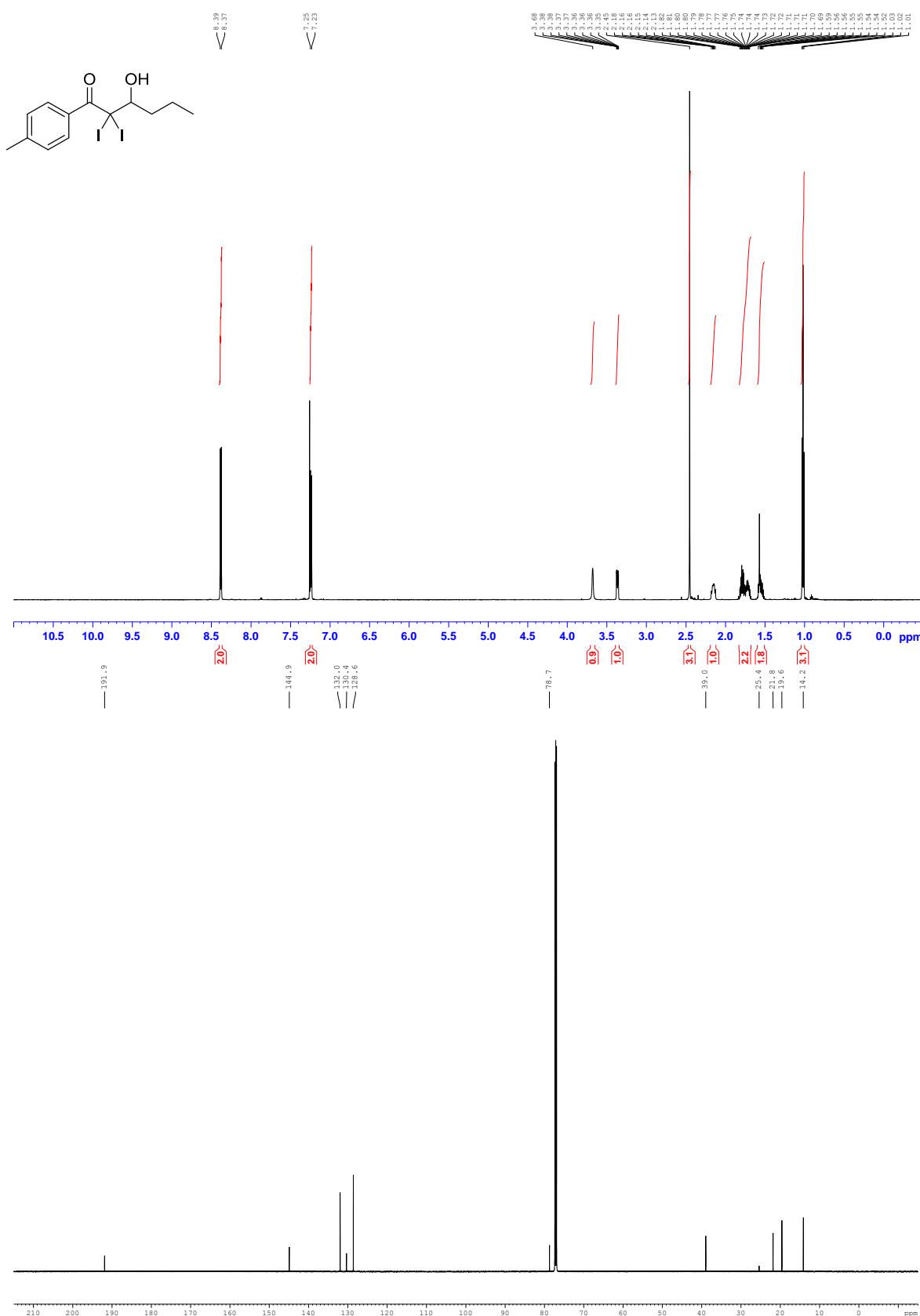
### 5-(*p*-Tolyl)pent-4-yne-1,3-diol (5f)



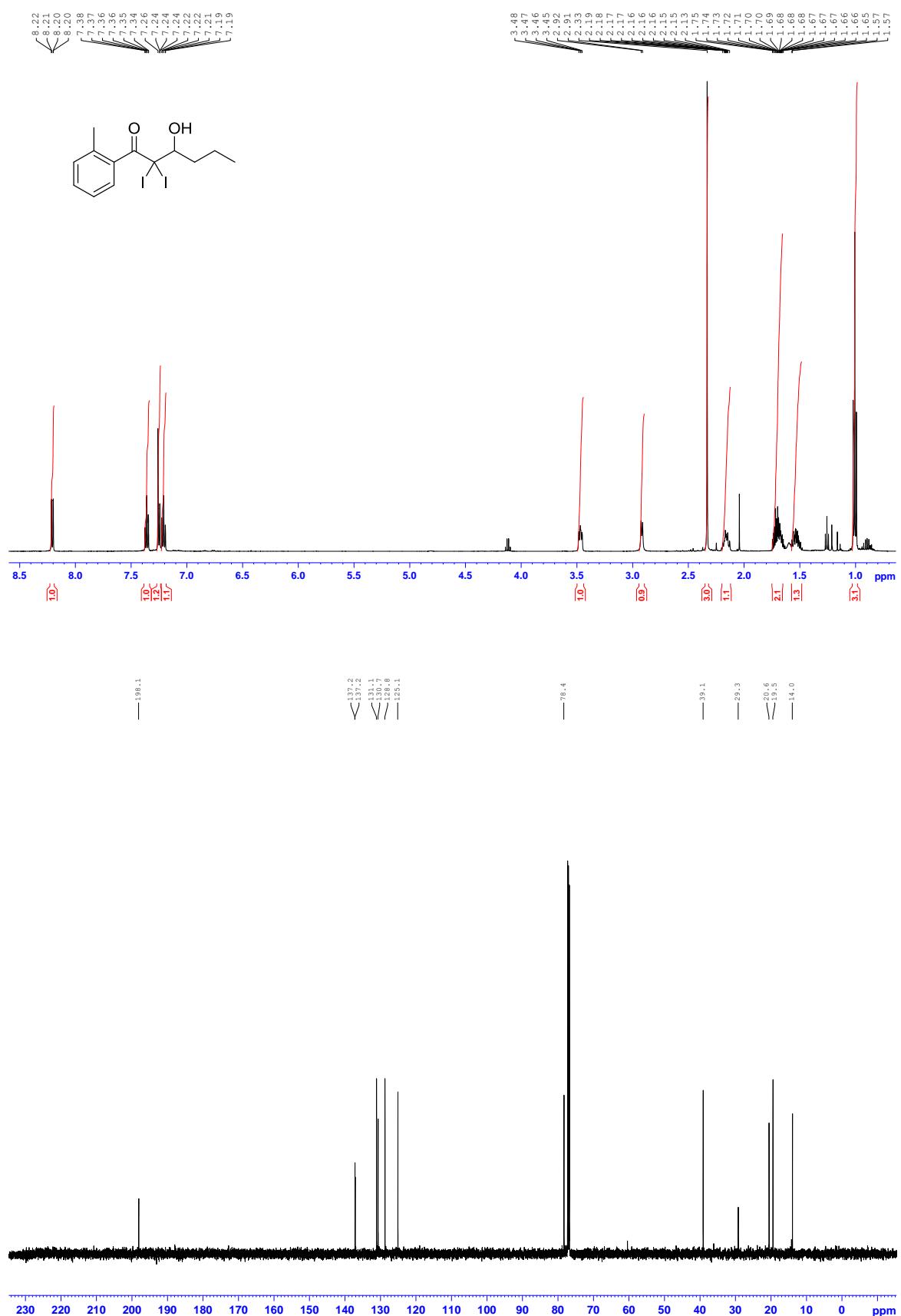
**(Z)-2-Iodo-1-(p-tolyl)hex-2-en-1-one (2a)**



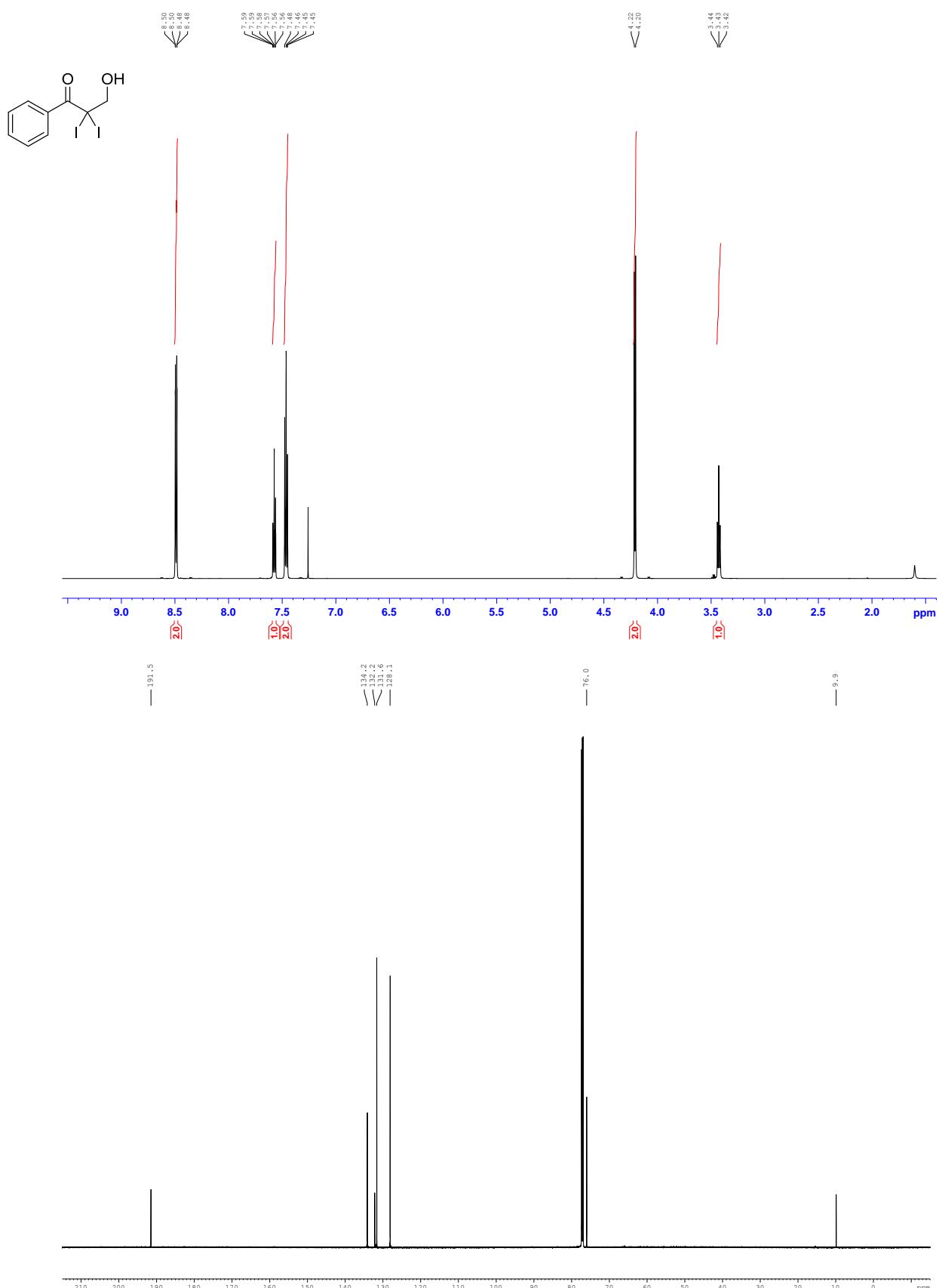
### 3-Hydroxy-2,2-diiodo-1-(*p*-tolyl)hexan-1-one (3a)



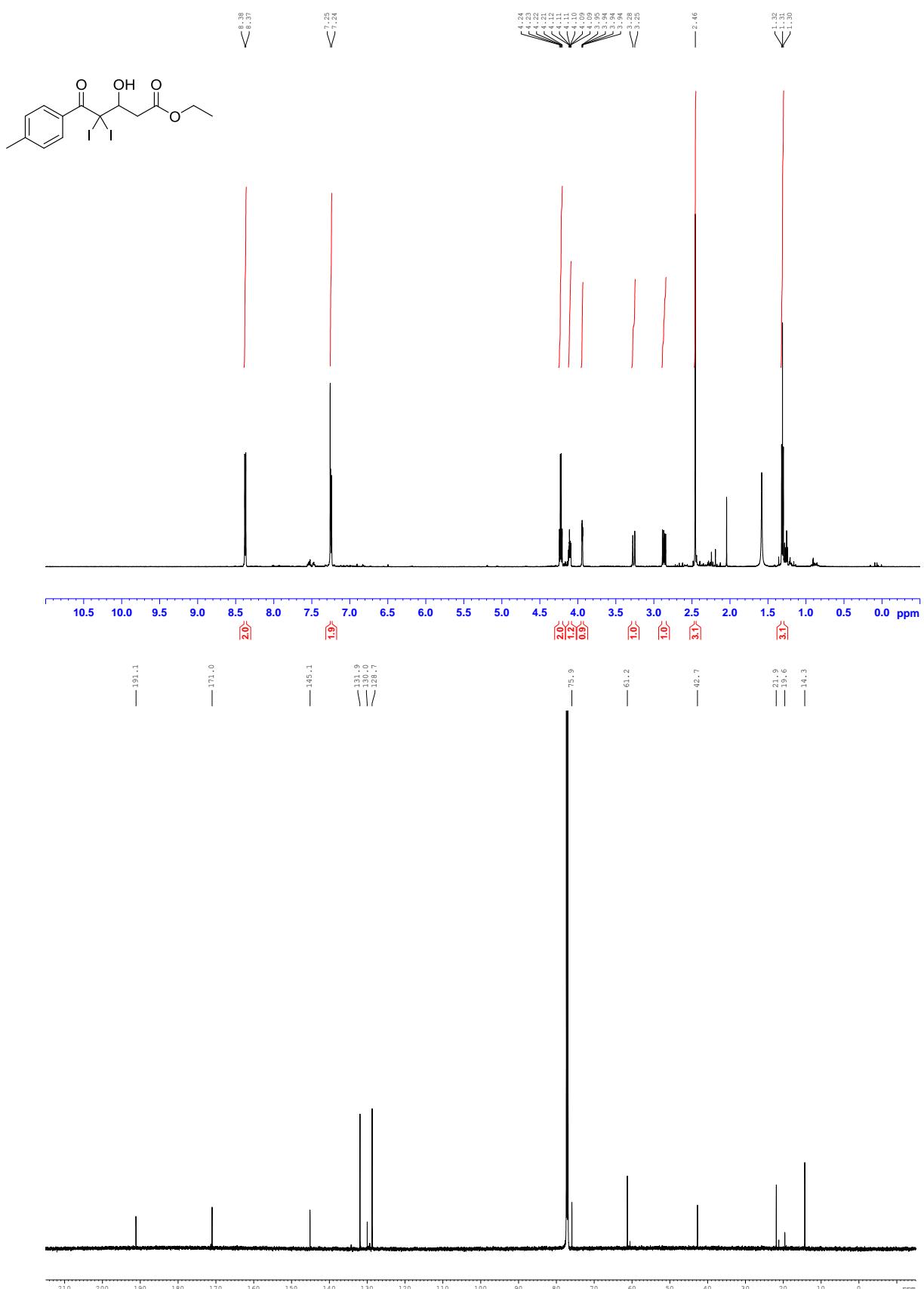
### 3-Hydroxy-2,2-diiodo-1-(*o*-tolyl)hexan-1-one (3b)



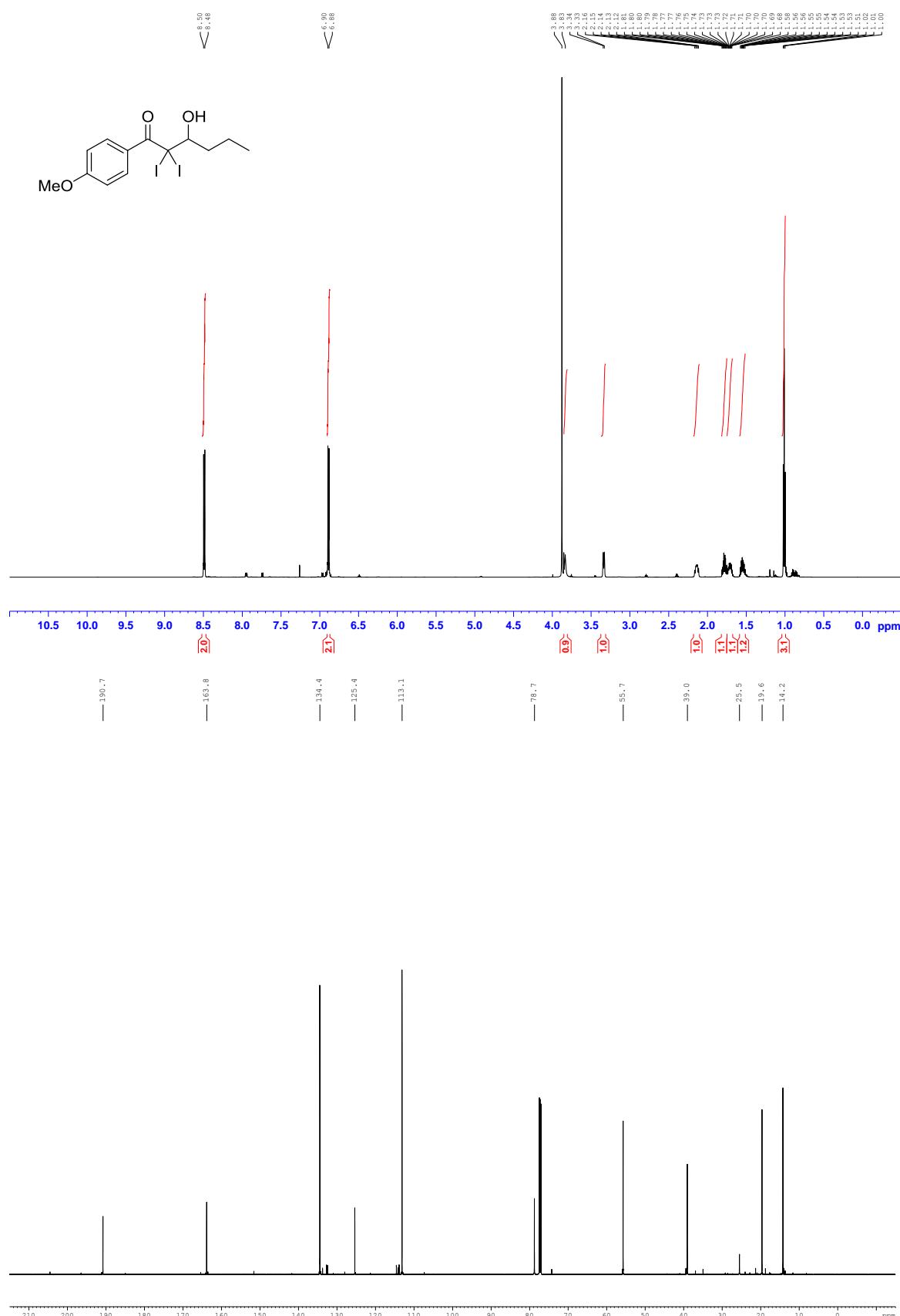
**3-Hydroxy-2,2-diodo-1-phenylpropan-1-one (3c)**



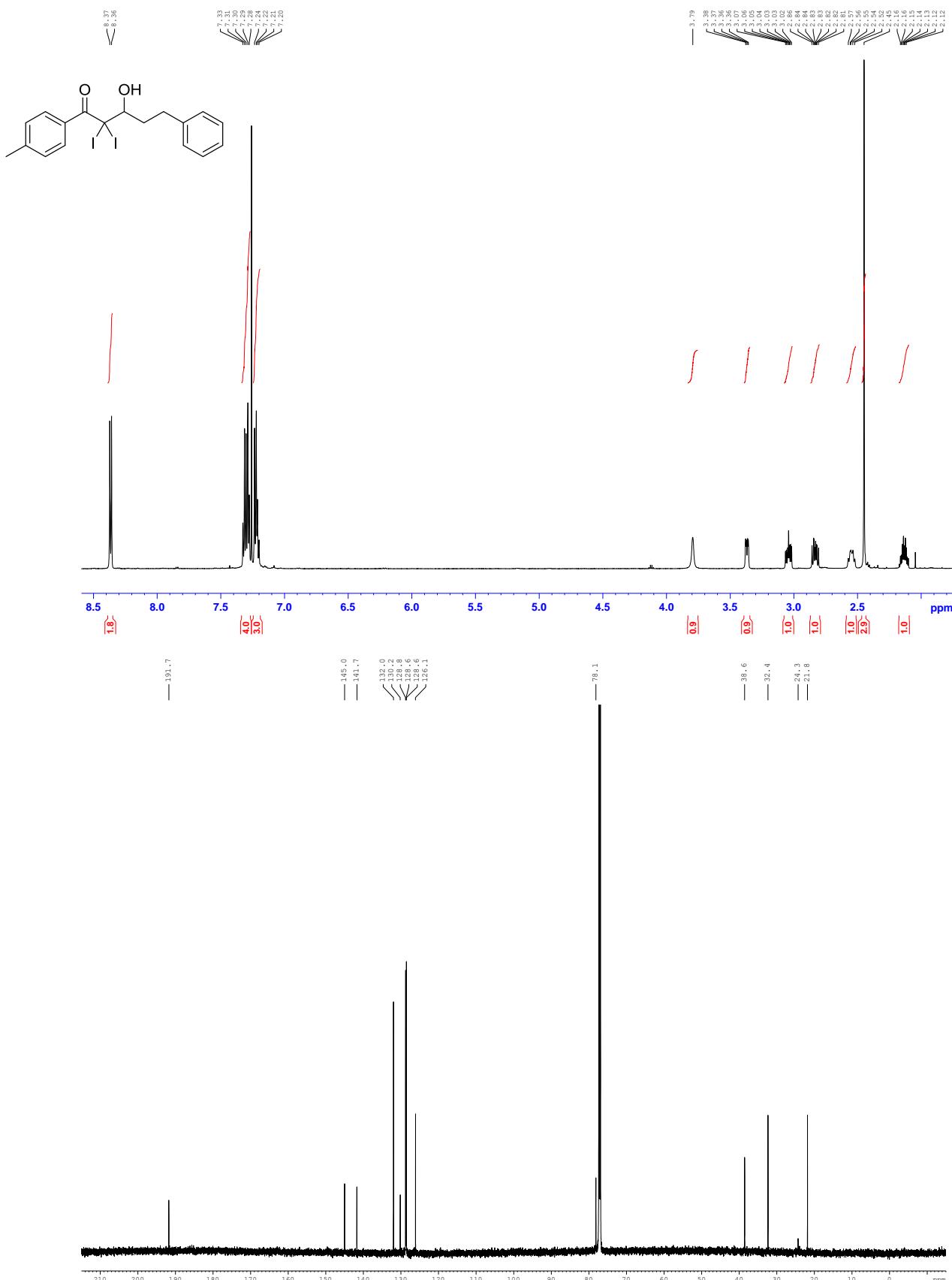
**Ethyl 3-hydroxy-4,4-diodo-5-oxo-5-(p-tolyl)pentanoate (3d)**



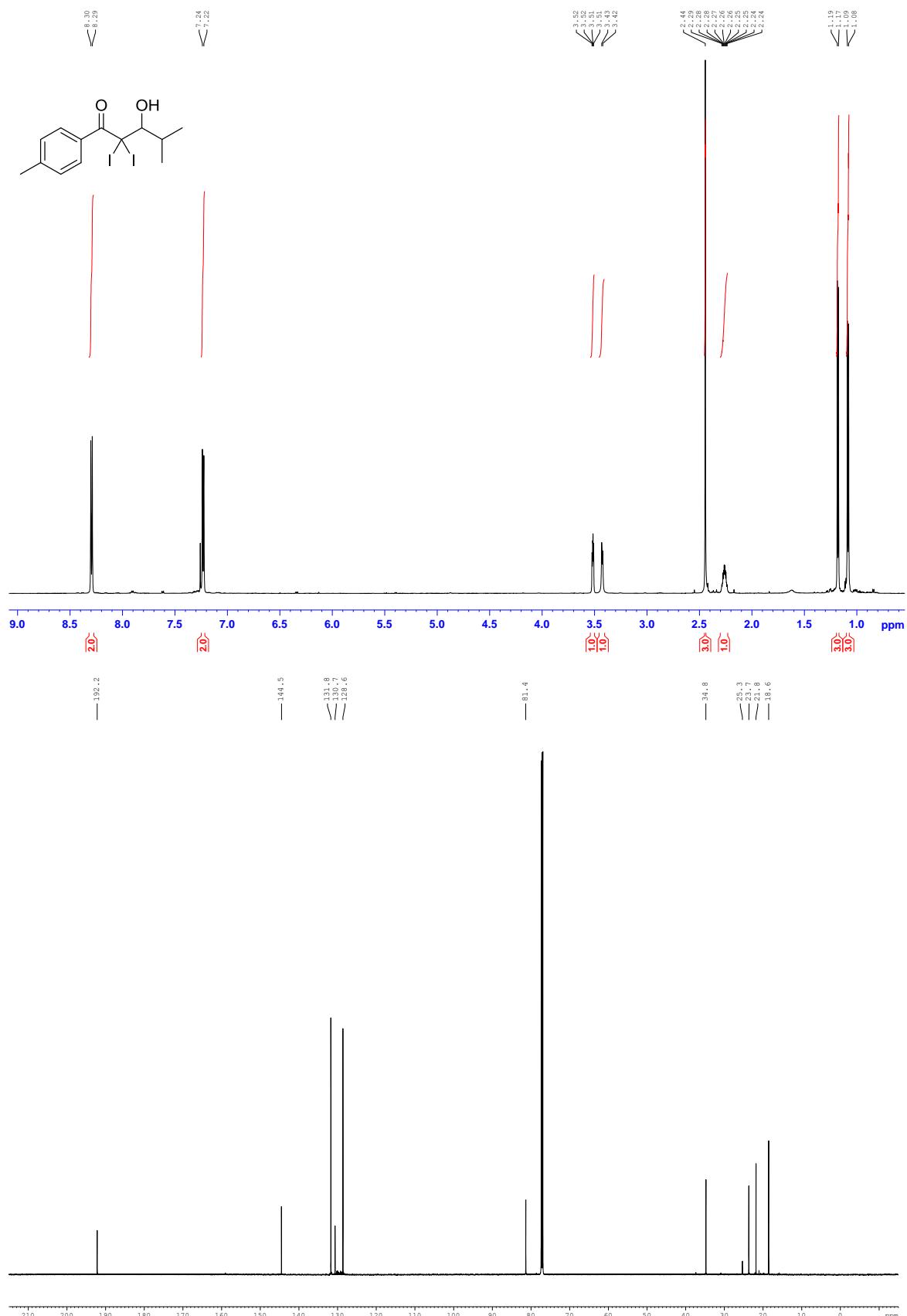
**3-Hydroxy-2,2-diiodo-1-(4-methoxyphenyl)hexan-1-one (3e)**



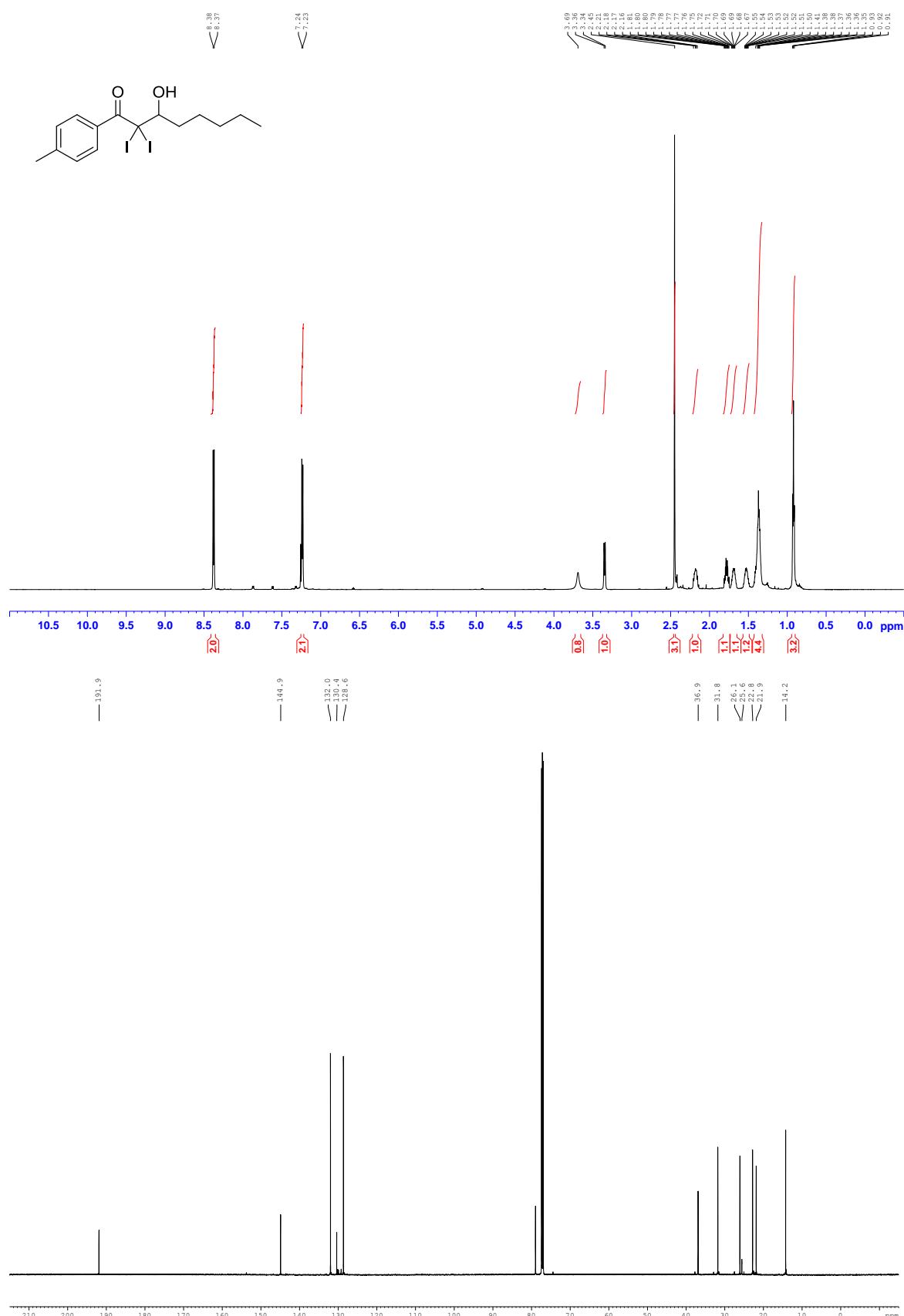
**3-Hydroxy-2,2-diiodo-5-phenyl-1-(p-tolyl)pentan-1-one (3f)**



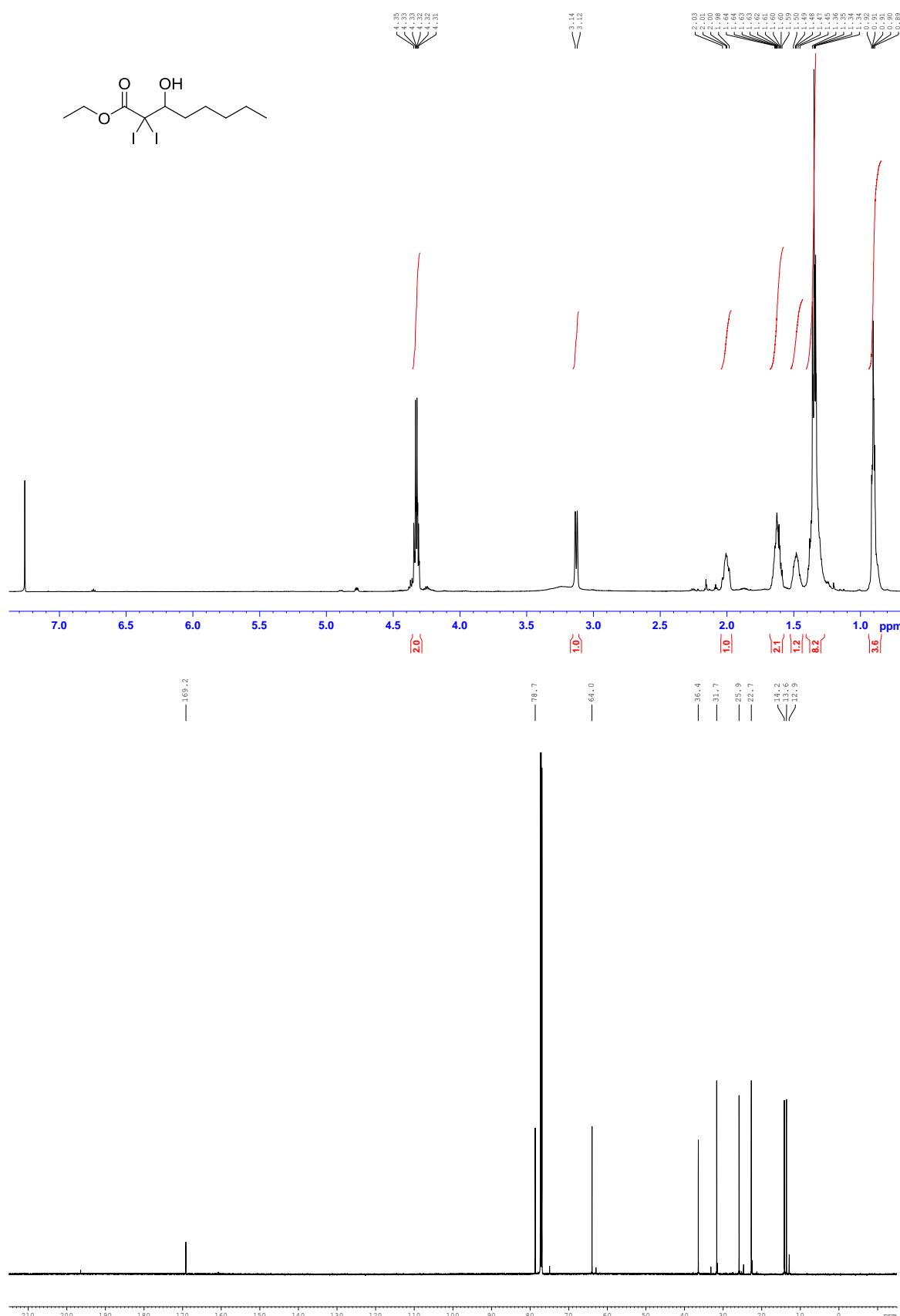
**3-Hydroxy-2,2-diodo-4-methyl-1-(p-tolyl)pentan-1-one (3g)**



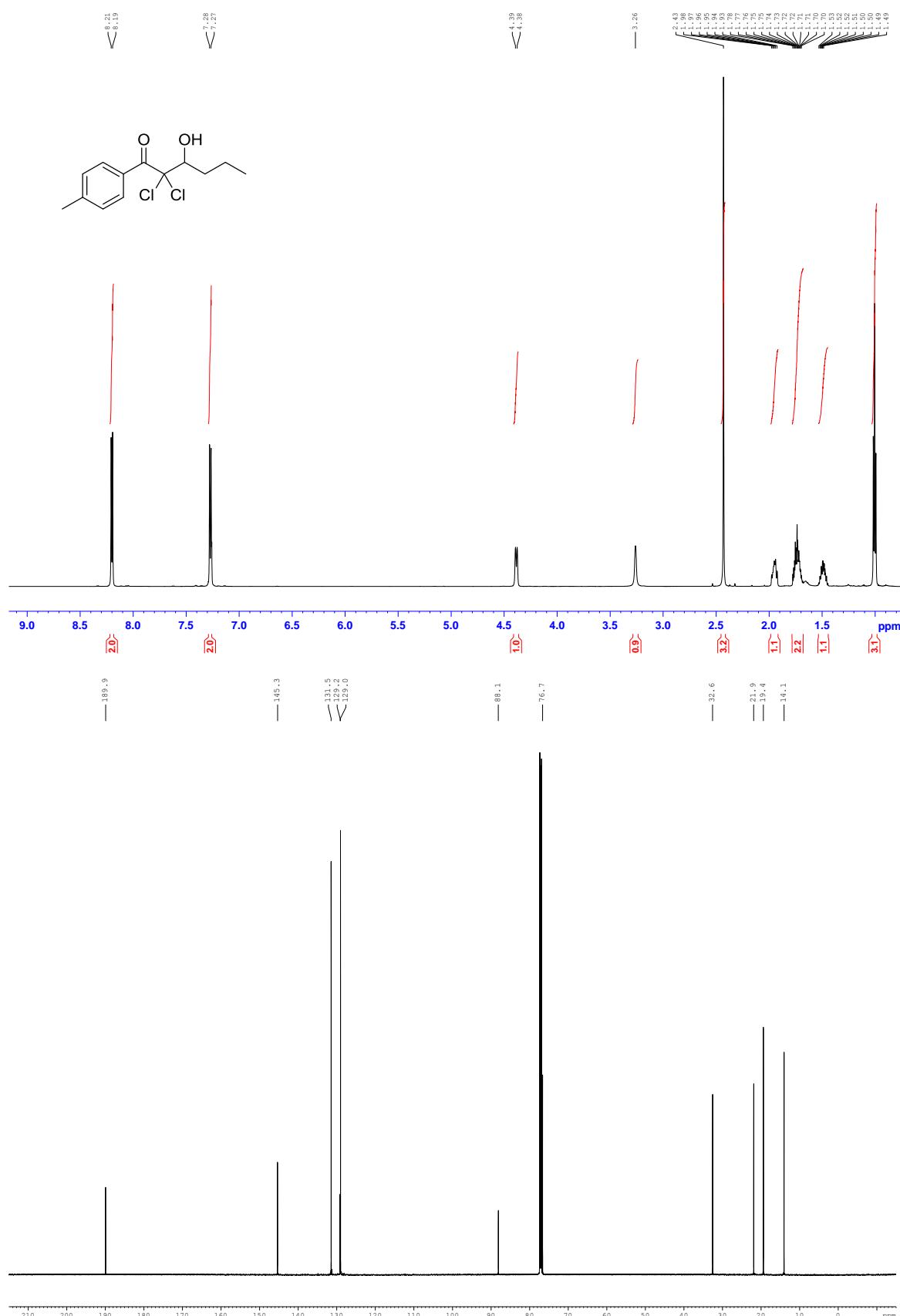
**3-Hydroxy-2,2-diodo-1-(p-tolyl)octan-1-one (3h)**



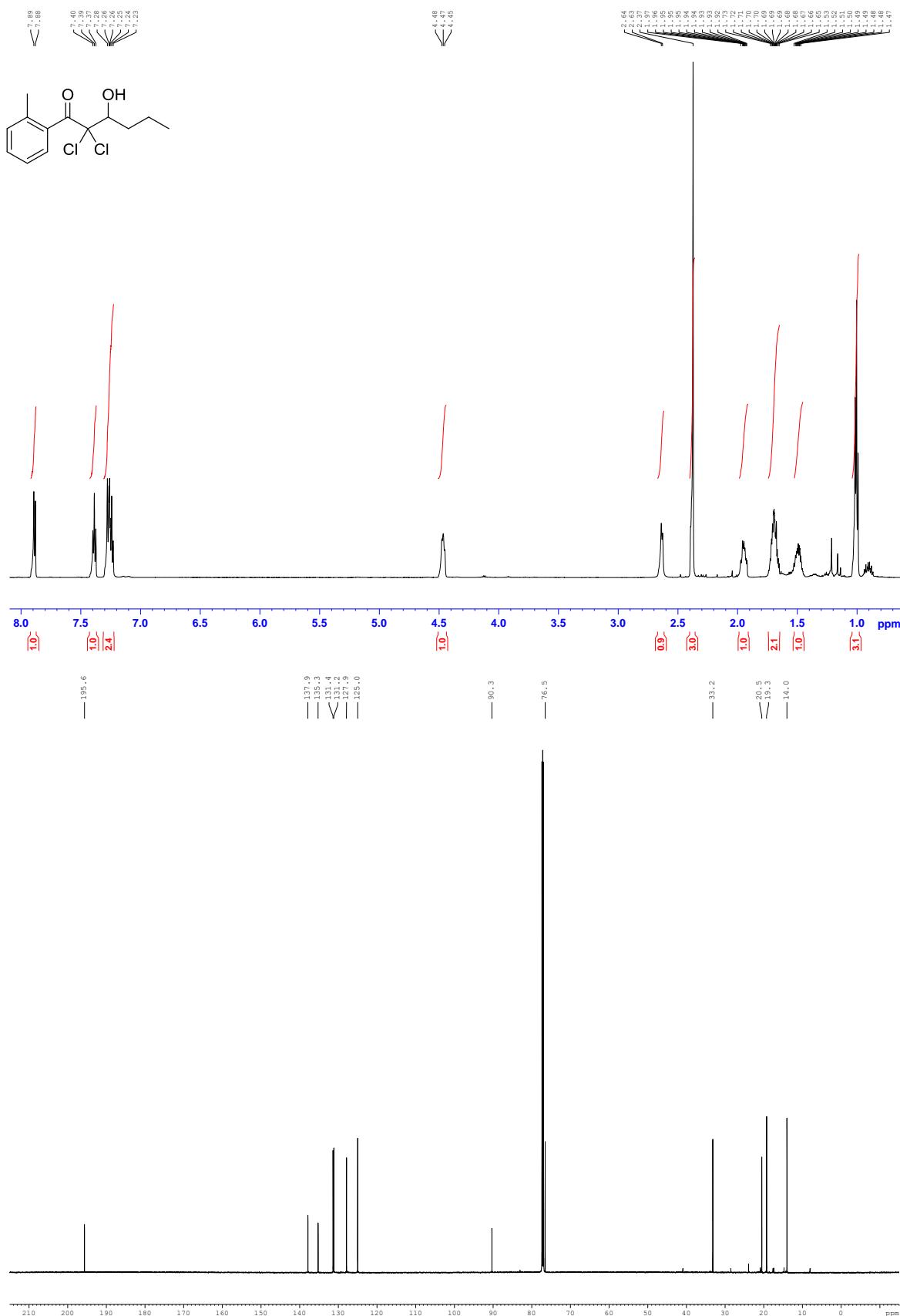
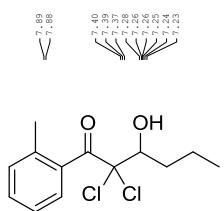
**Ethyl 3-hydroxy-2,2-diiodooctanoate (3i)**



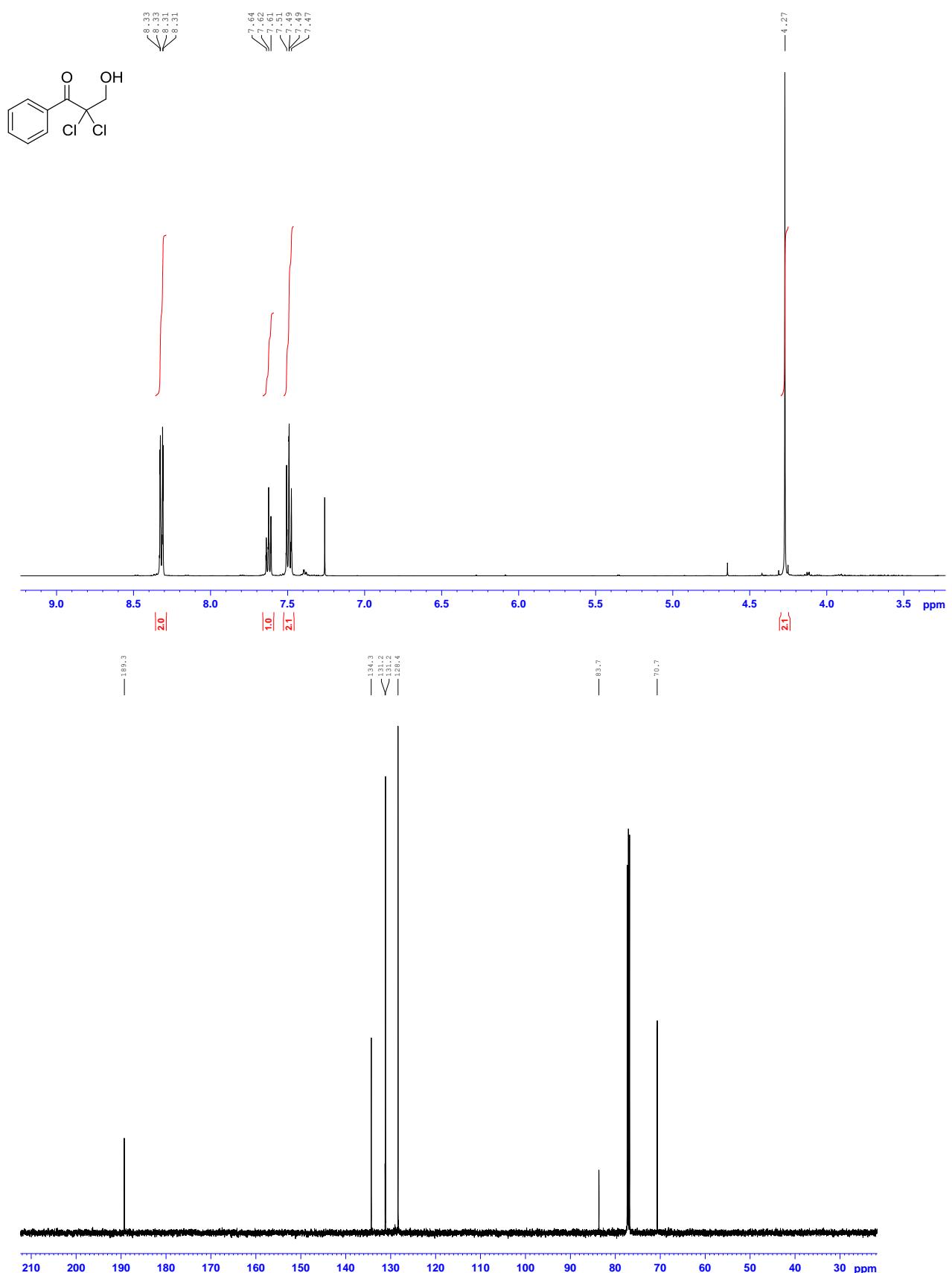
### **2,2-Dichloro-3-hydroxy-1-(*p*-tolyl)hexan-1-one (4a)**



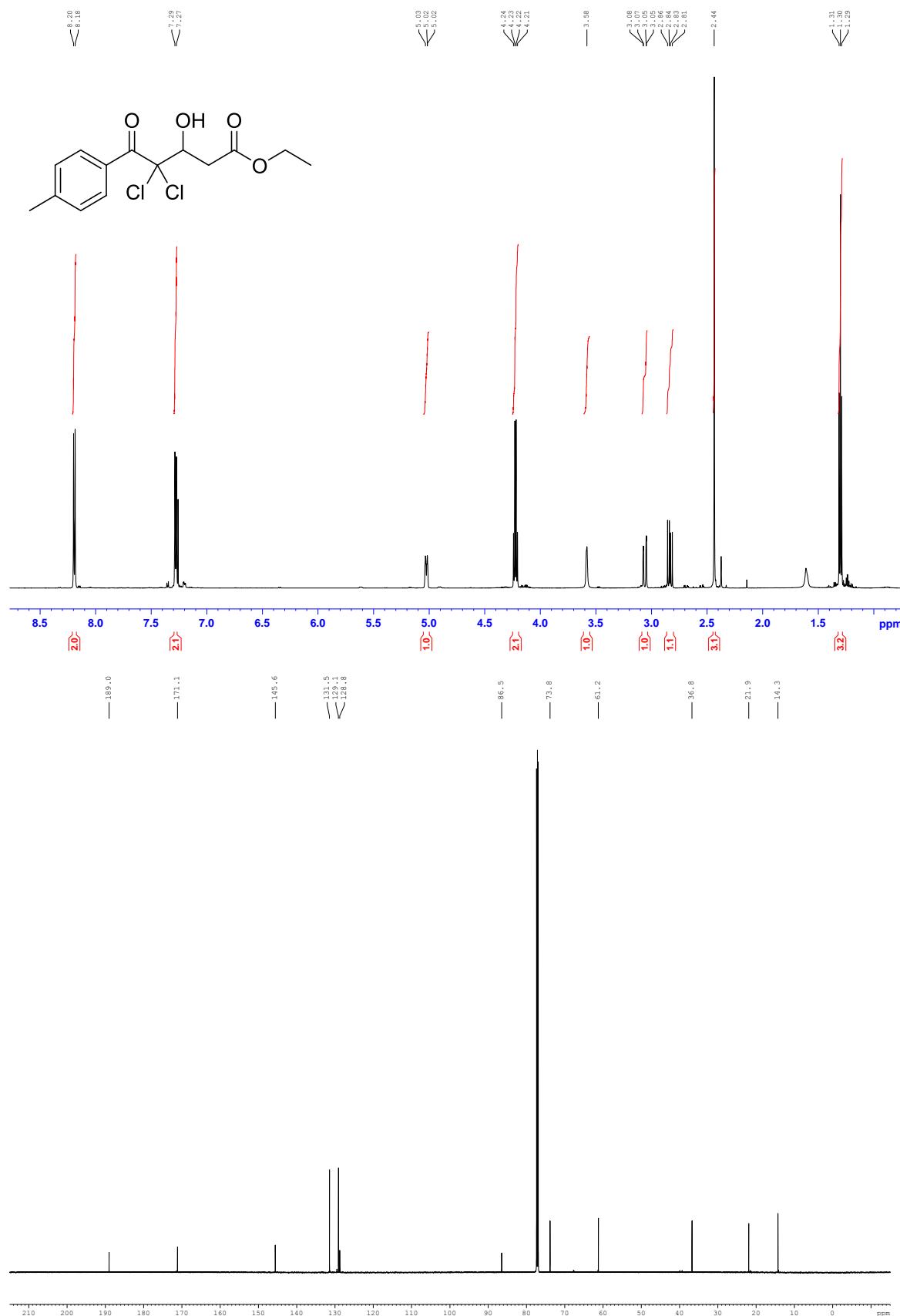
### 3-Hydroxy-2,2-dichloro-1-(*o*-tolyl)hexan-1-one (4b)



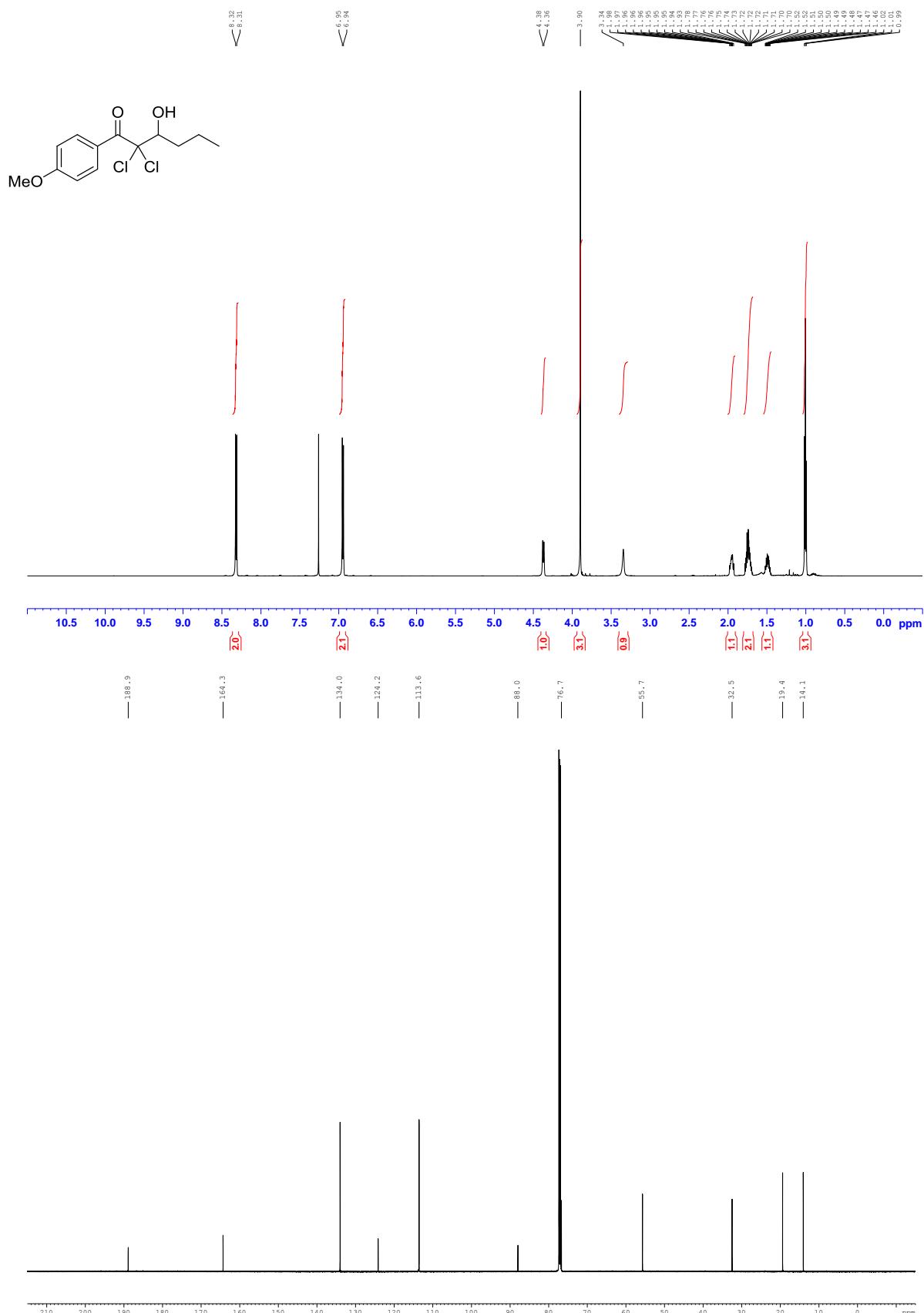
**2,2-Dichloro-3-hydroxy-1-phenylpropan-1-one (4c)**



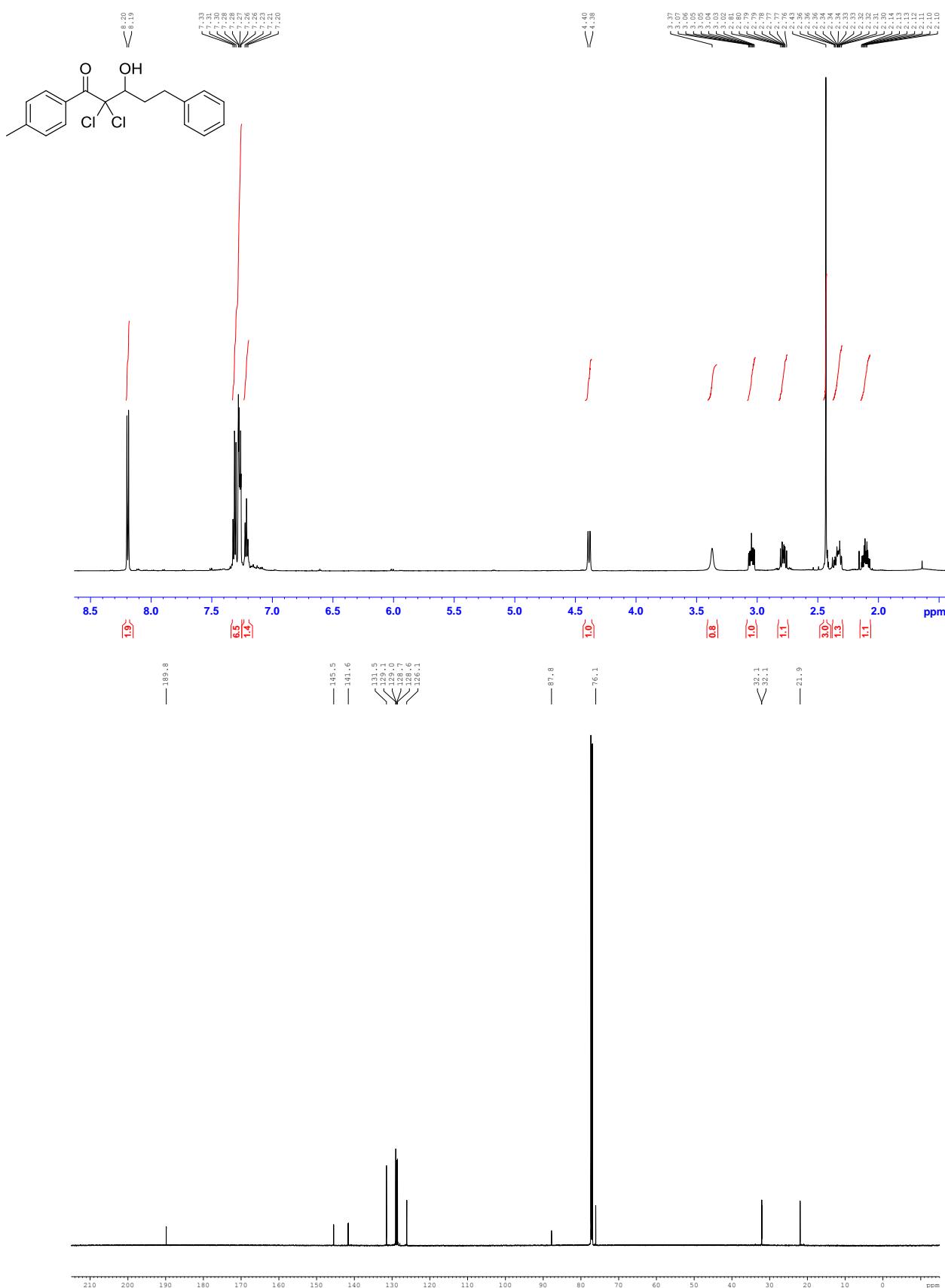
### Ethyl 4,4-dichloro-3-hydroxy-5-oxo-5-(p-tolyl)pentanoate (4d)



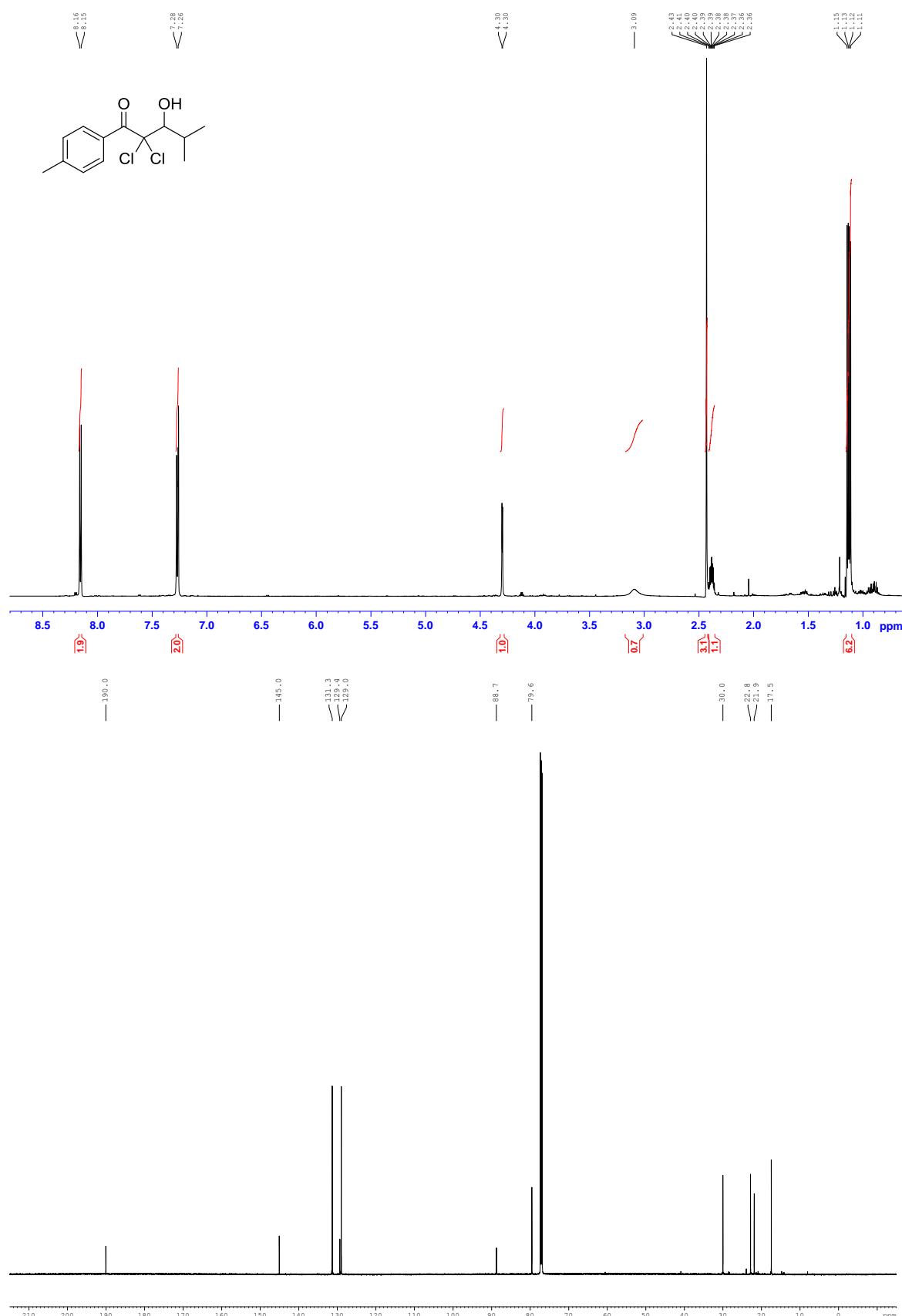
**3-Hydroxy-2,2-dichloro-1-(4-methoxyphenyl)hexan-1-one (4e)**



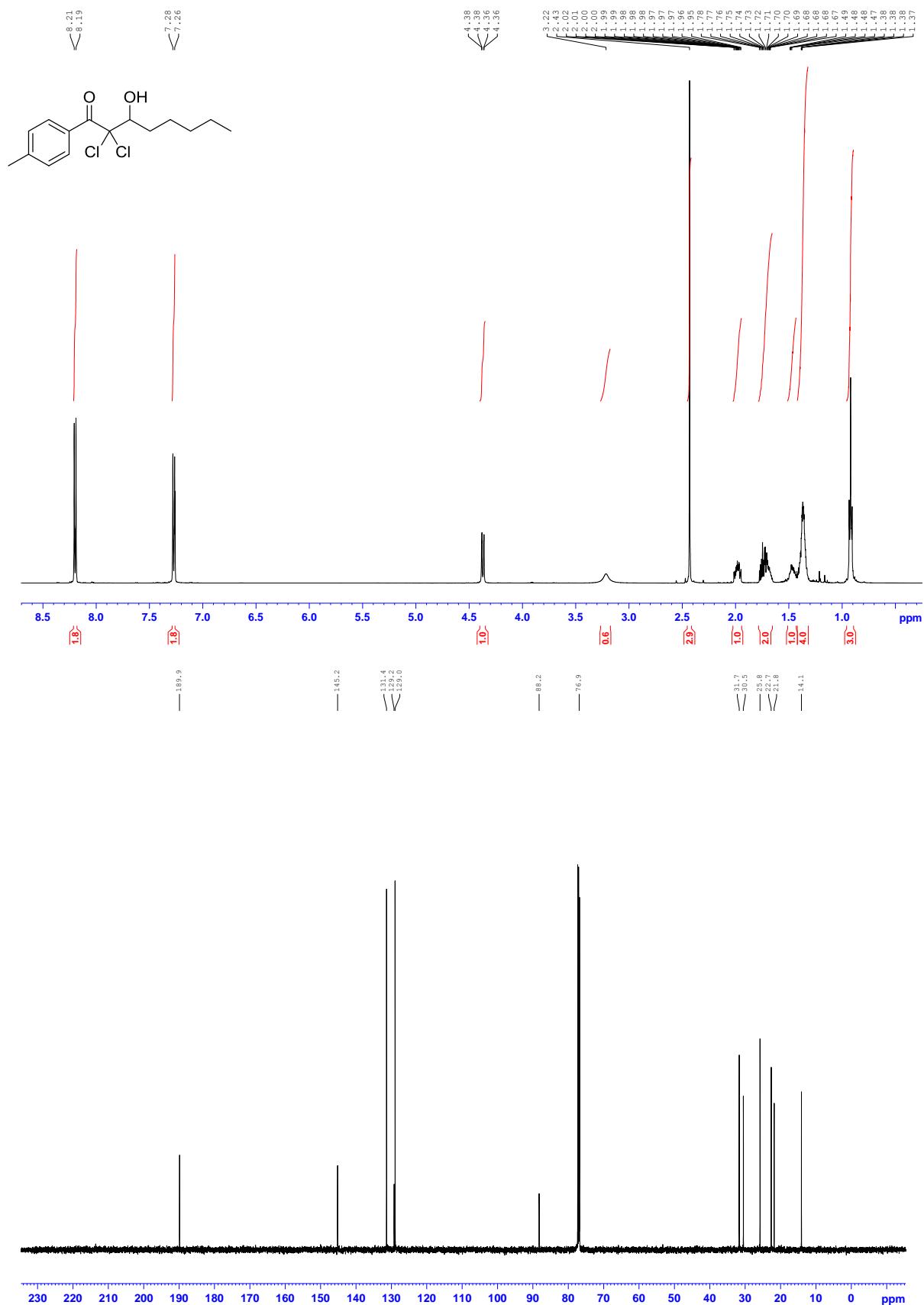
### 3-Hydroxy-2,2-dichloro-5-phenyl-1-(*p*-tolyl)pentan-1-one (4f)



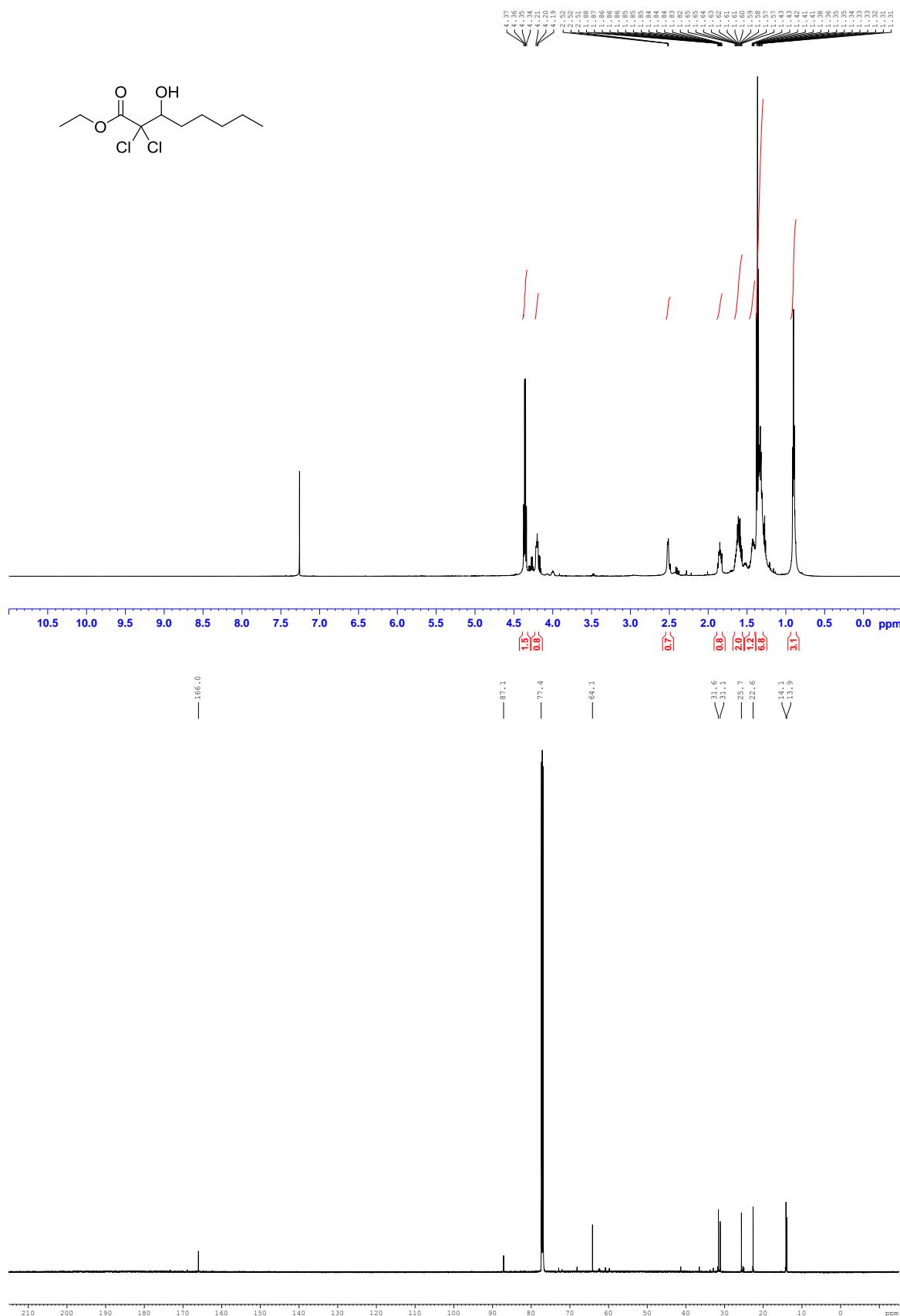
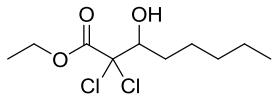
**2,2-Dichloro-3-hydroxy-4-methyl-1-(p-tolyl)pentan-1-one (4g)**



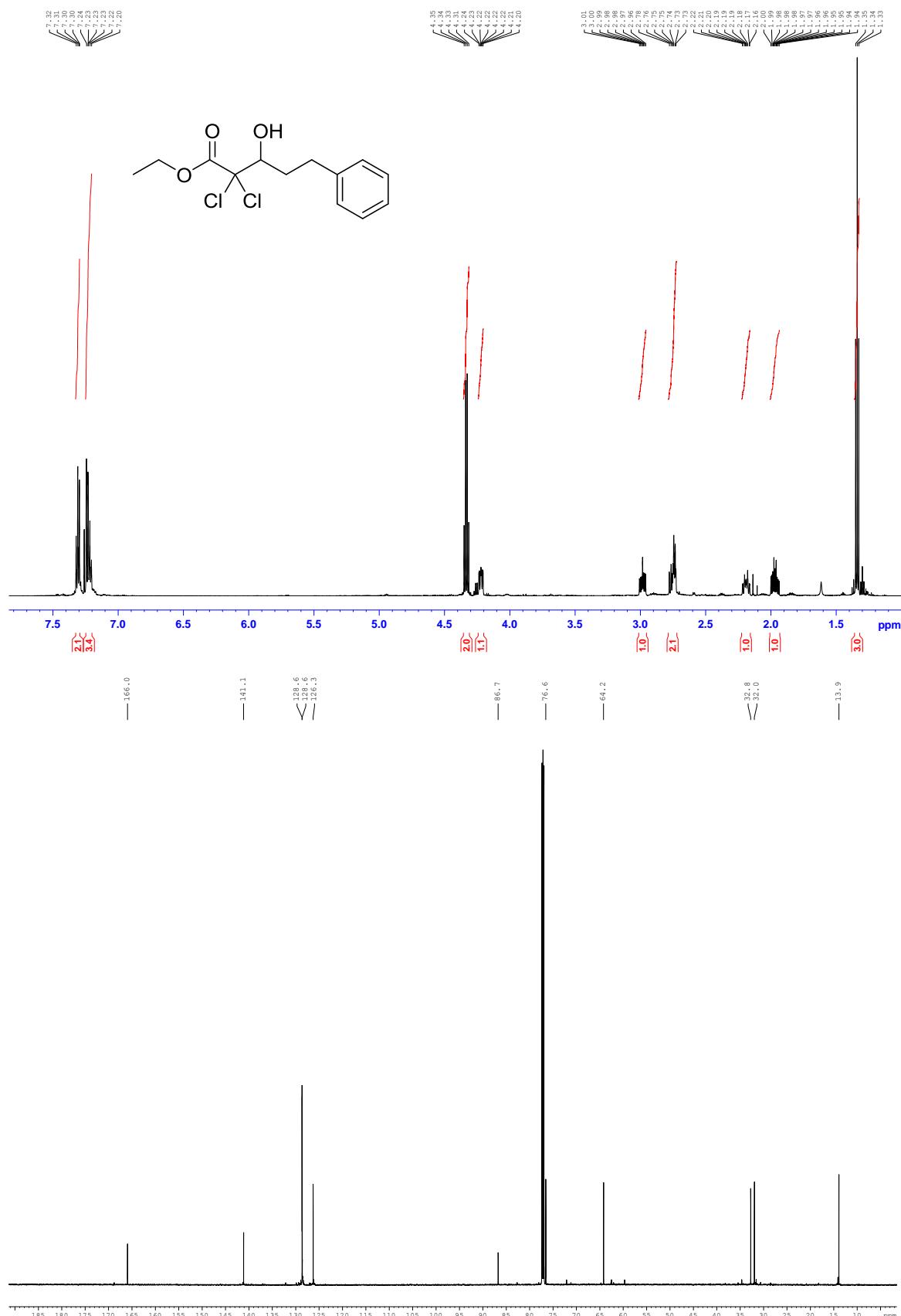
### **2,2-Dichloro-3-hydroxy-1-(*p*-tolyl)octan-1-one (4h)**



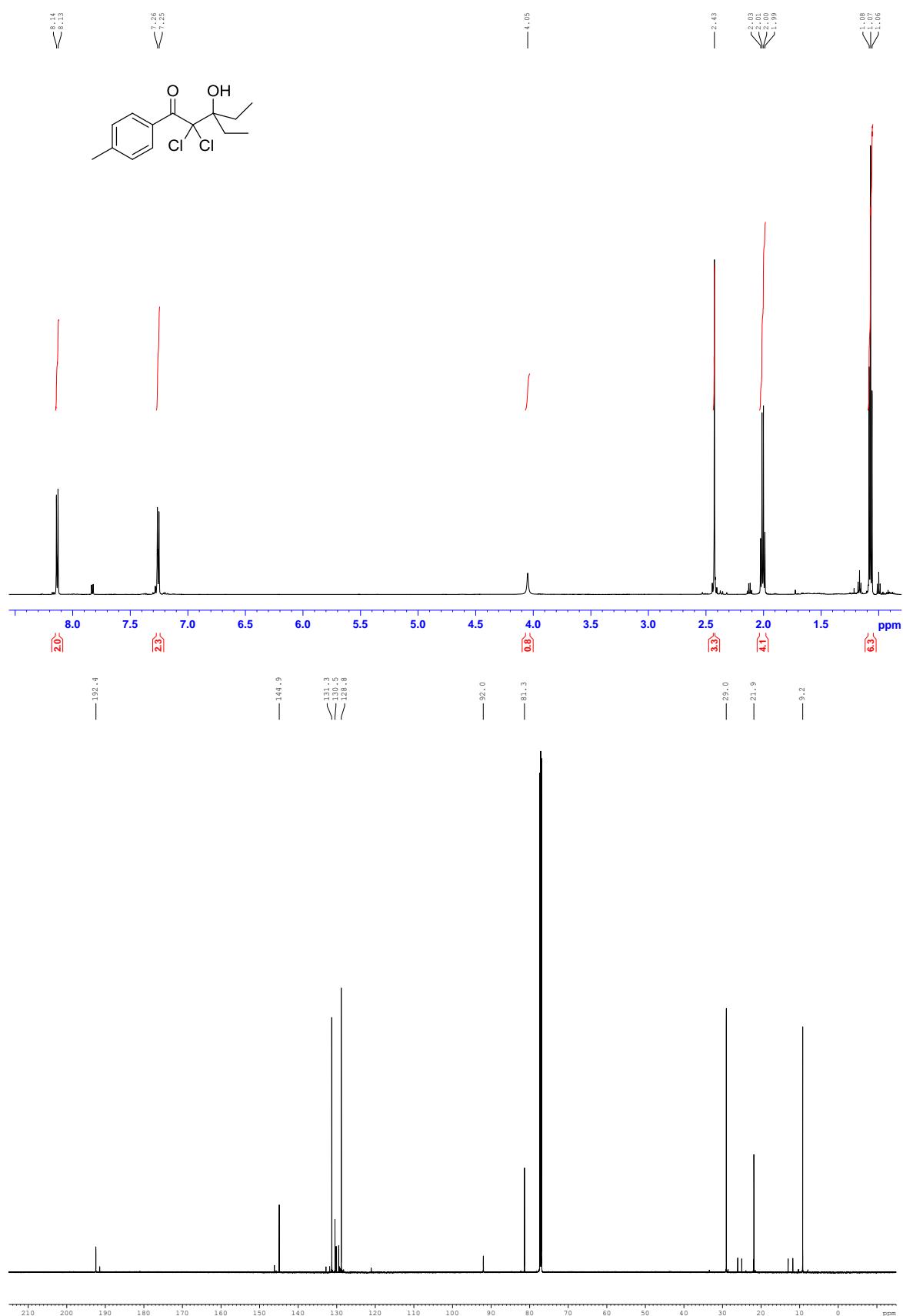
### Ethyl 2,2-dichloro-3-hydroxyoctanoate (4i)



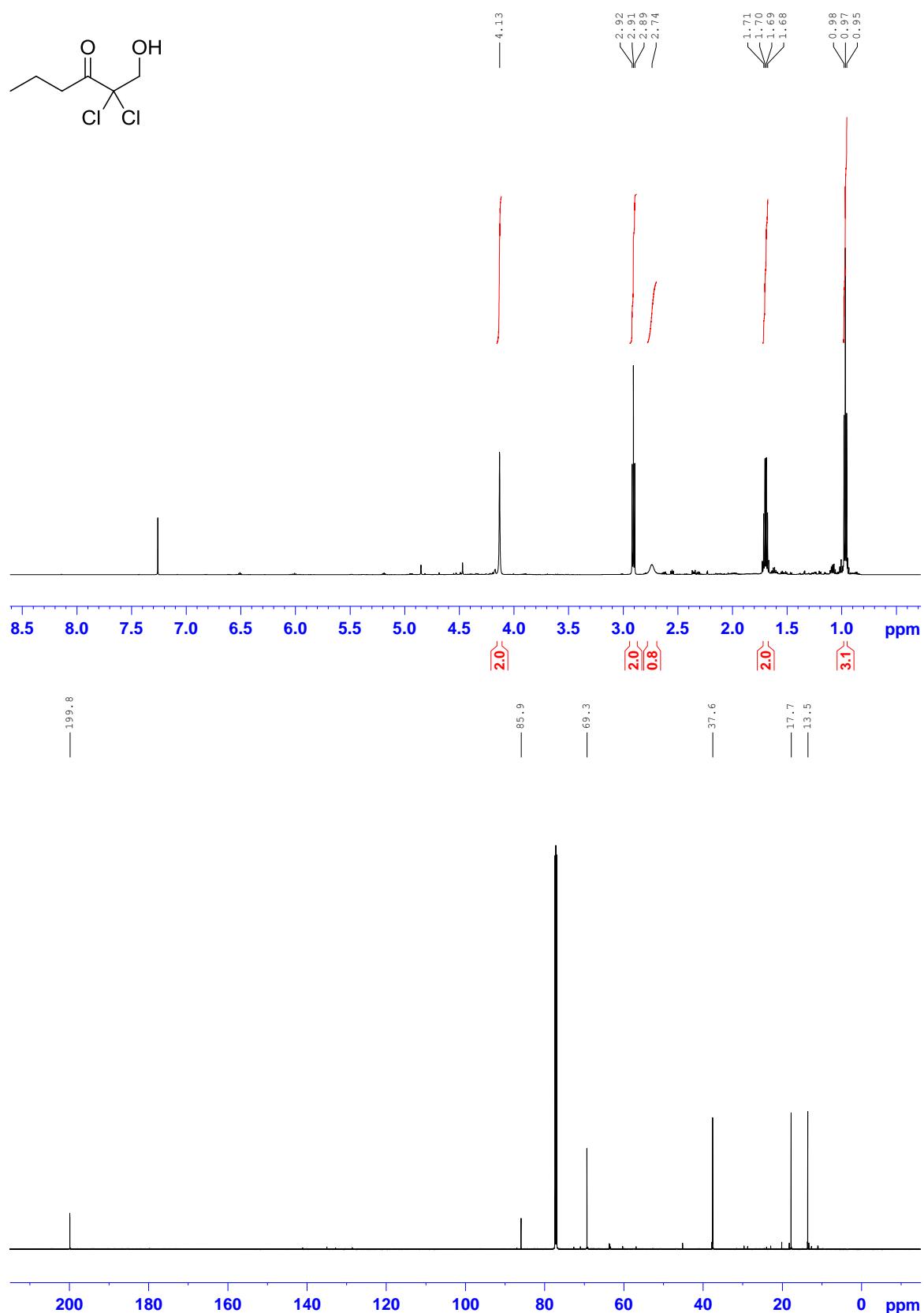
### Ethyl 2,2-dichloro-3-hydroxy-5-phenylpentanoate (4j)



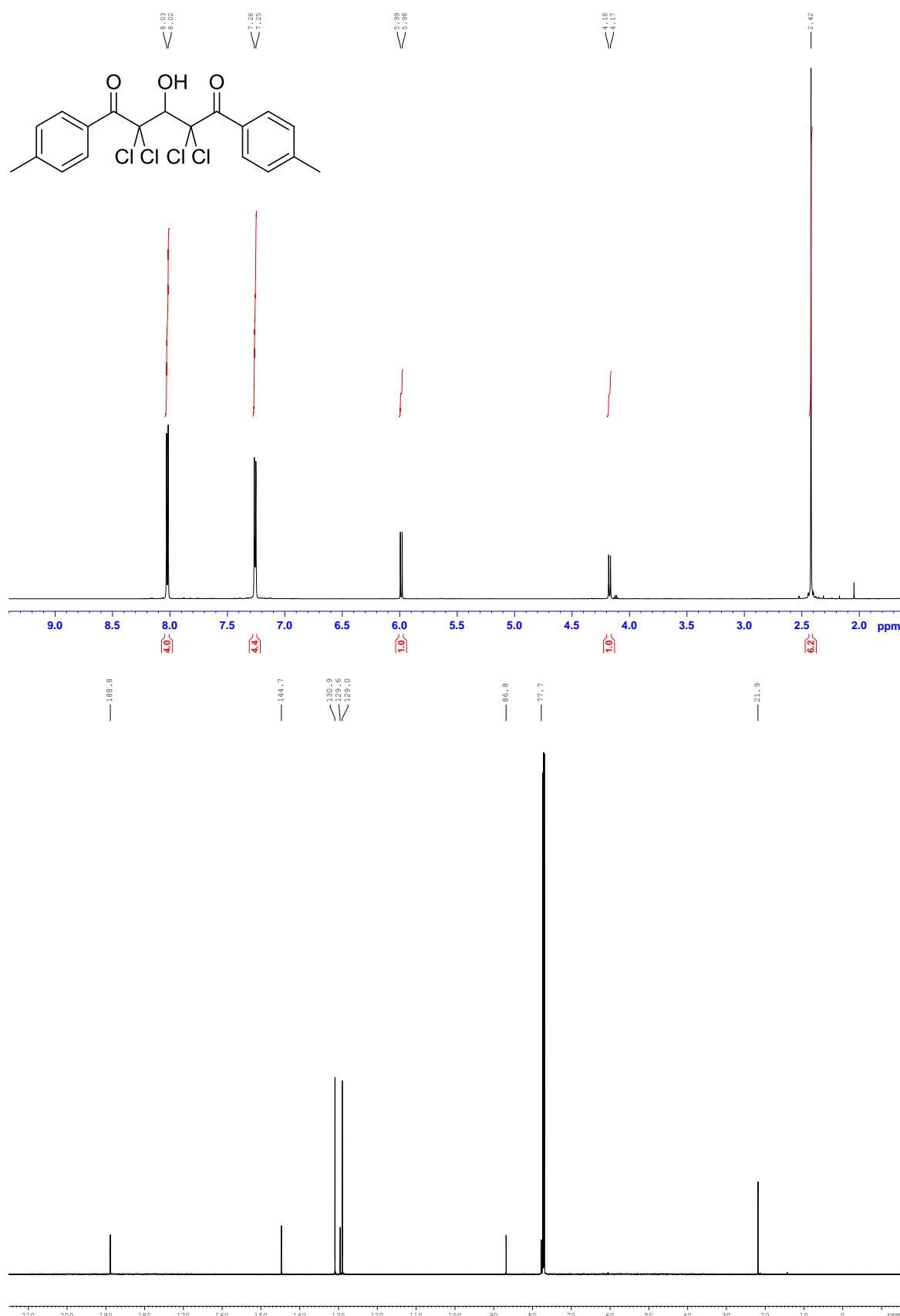
**2,2-Dichloro-3-ethyl-3-hydroxy-1-(p-tolyl)pentan-1-one (4k)**



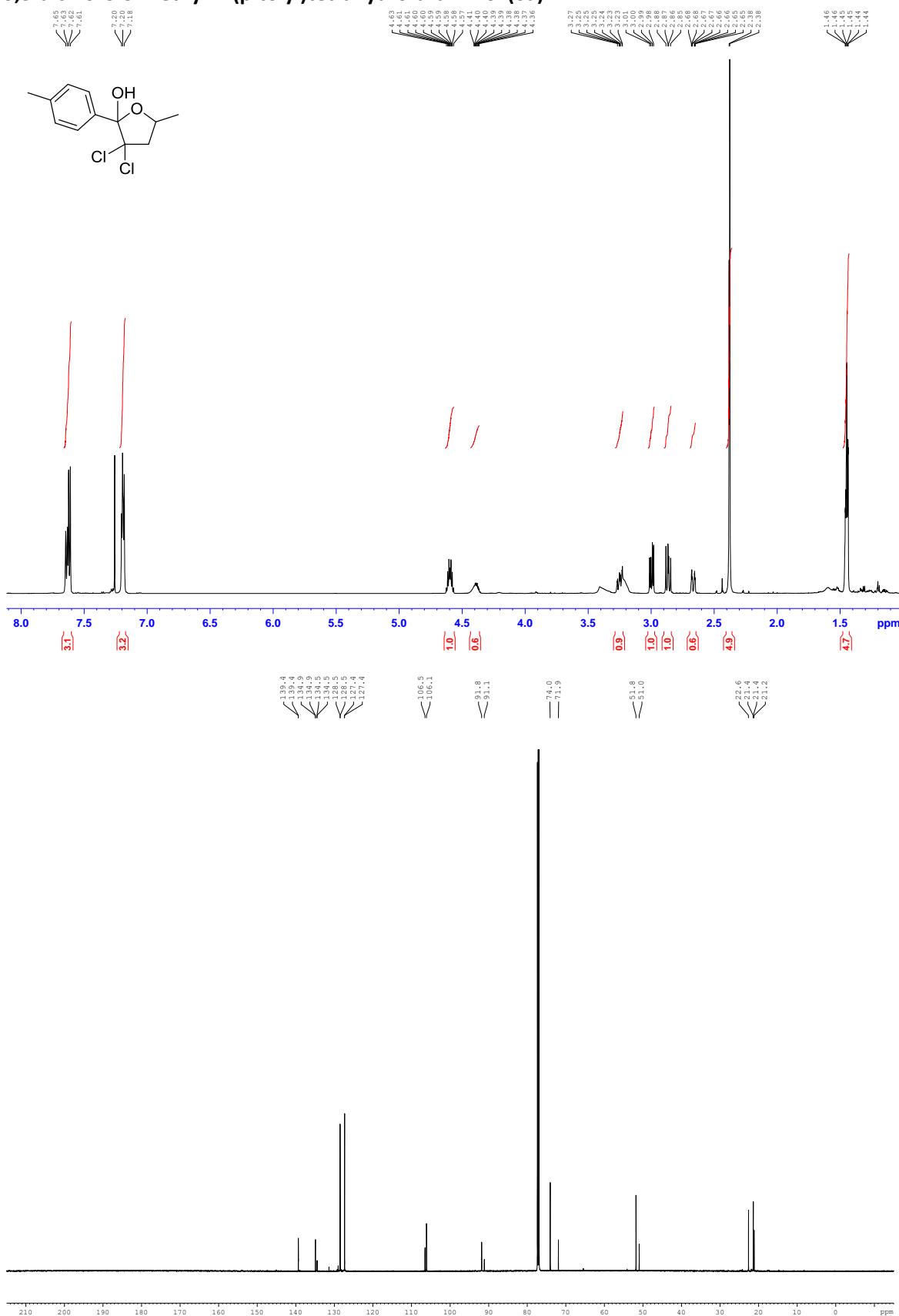
**2,2-Dichloro-1-hydroxyhexan-3-one (4l)**



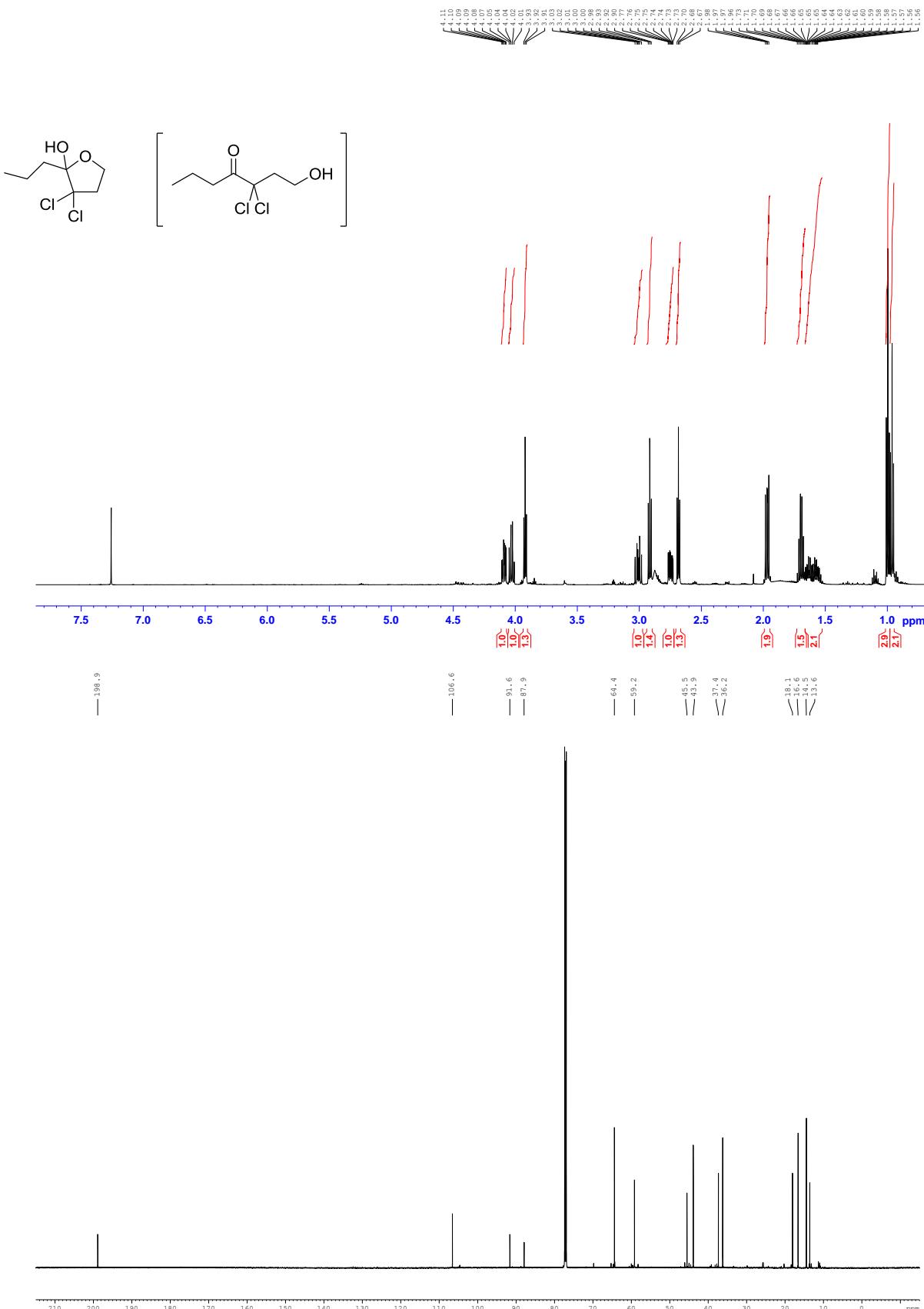
**2,2,4,4-Tetrachloro-3-hydroxy-1,5-di-p-tolylpentane-1,5-dione (4m)**



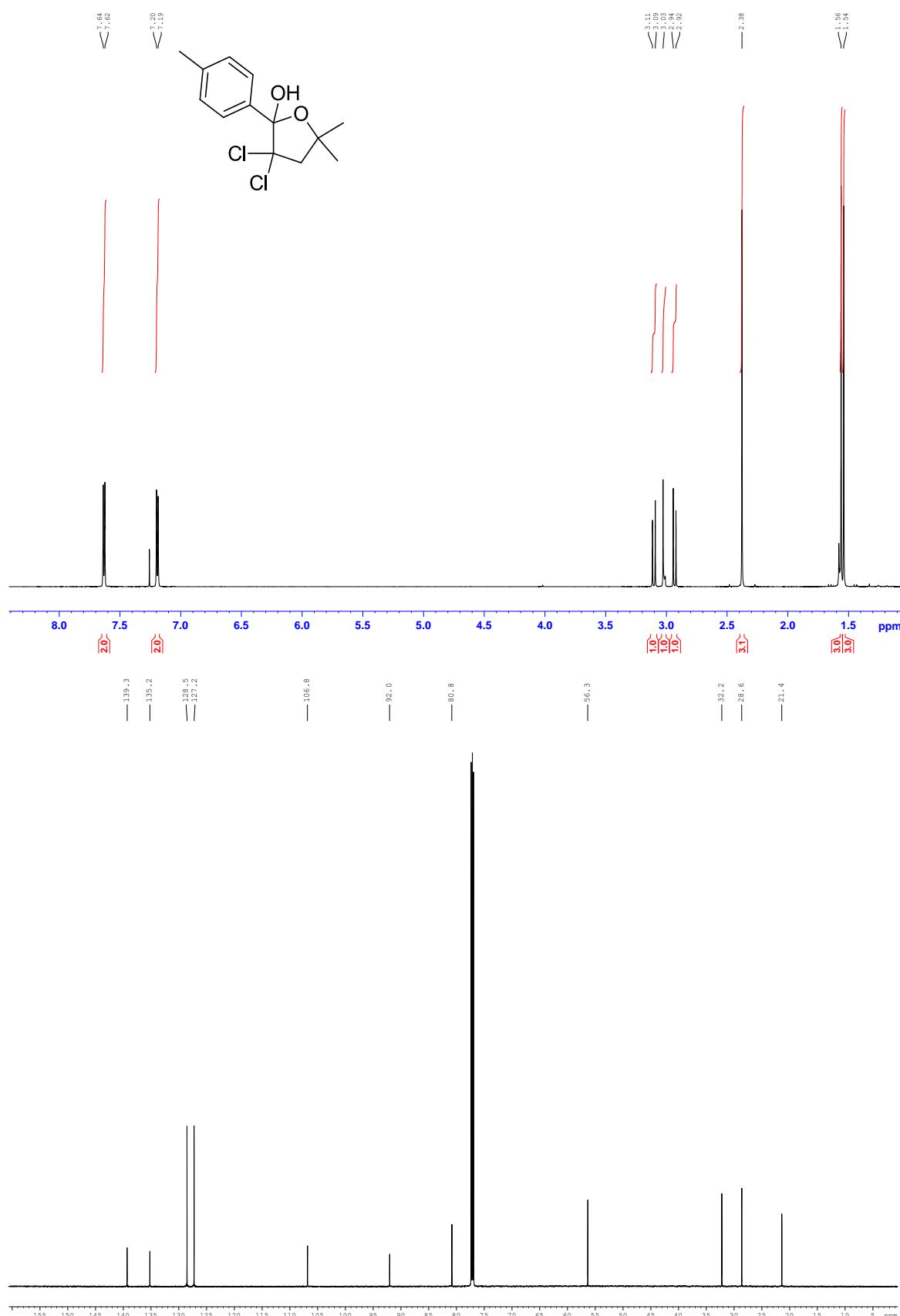
### 3,3-dichloro-5-methyl-2-(p-tolyl)tetrahydrofuran-2-ol (6a)



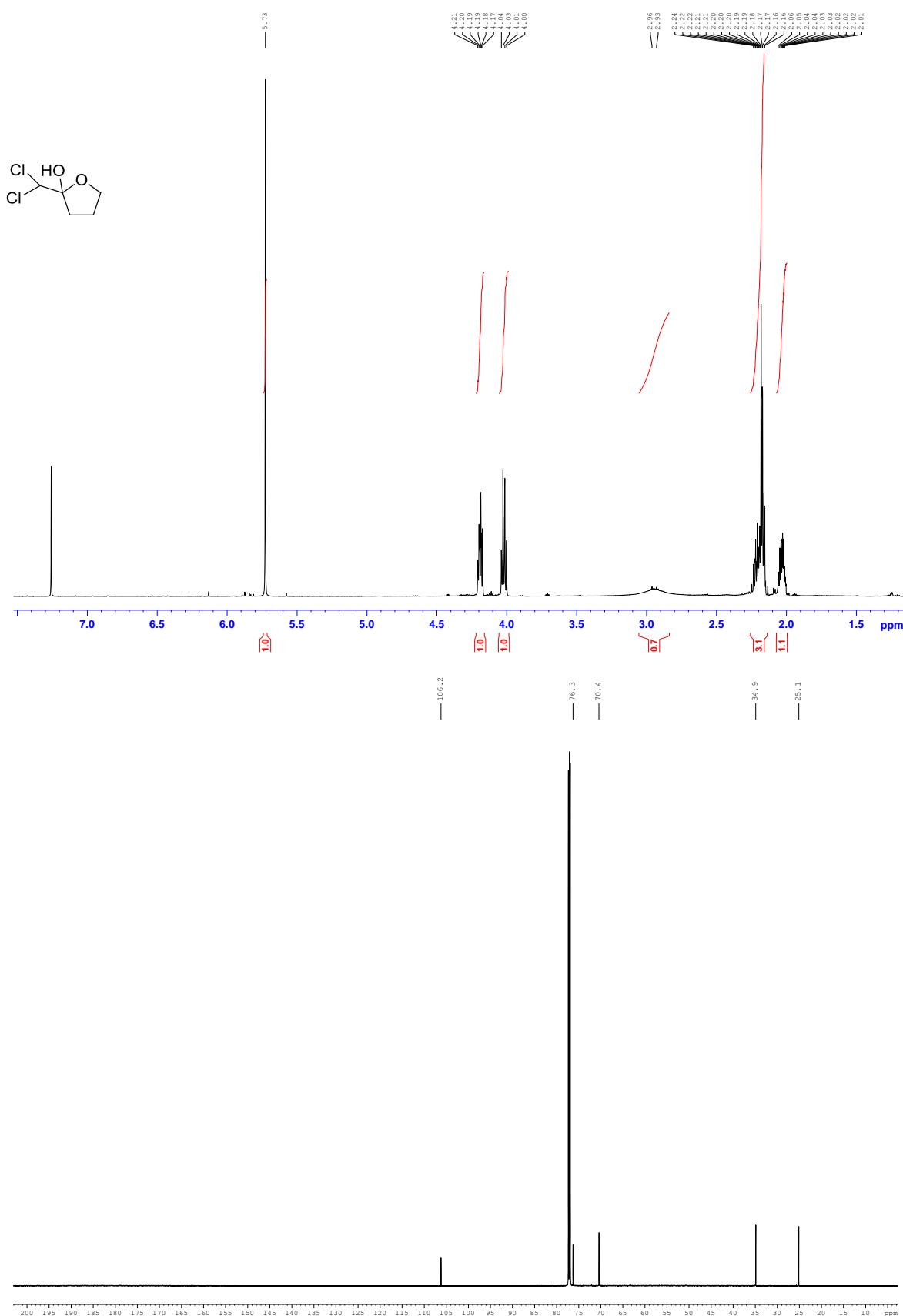
### **3,3-dichloro-2-propyltetrahydrofuran-2-ol (6b)**



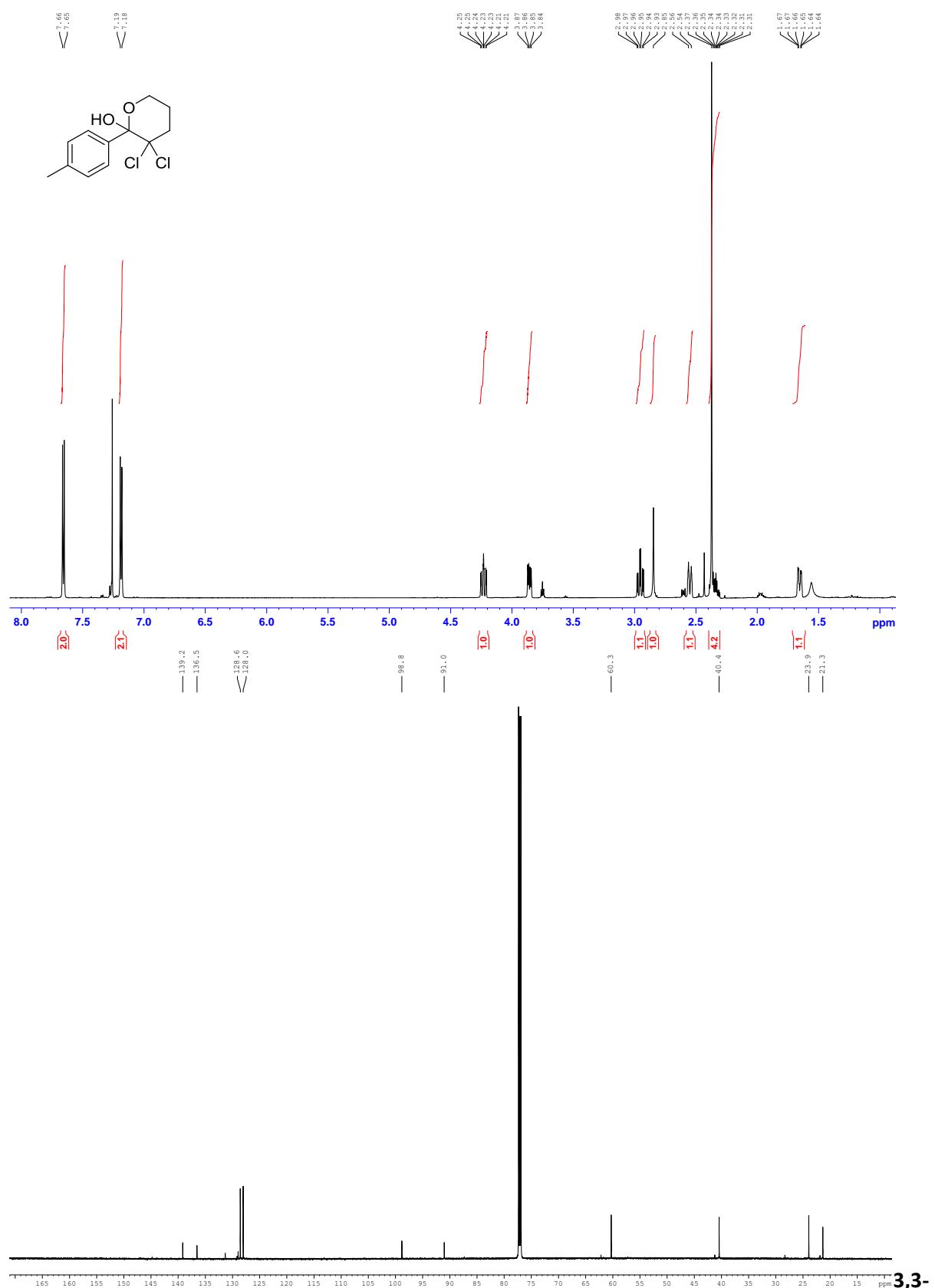
**3,3-Dichloro-5,5-dimethyl-2-(p-tolyl)tetrahydrofuran-2-ol (6c)**



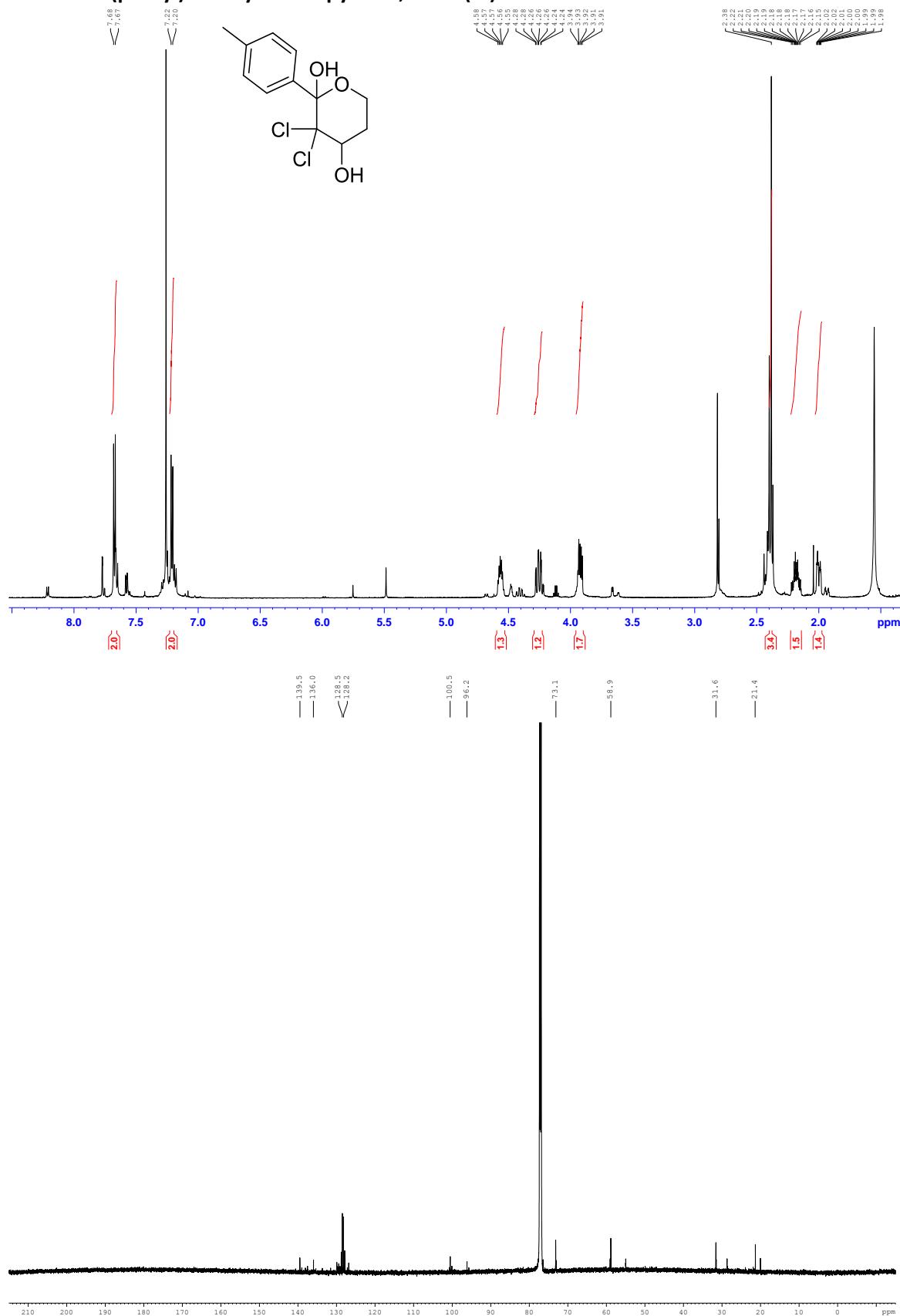
**2-(dichloromethyl)tetrahydrofuran-2-ol (6d)**



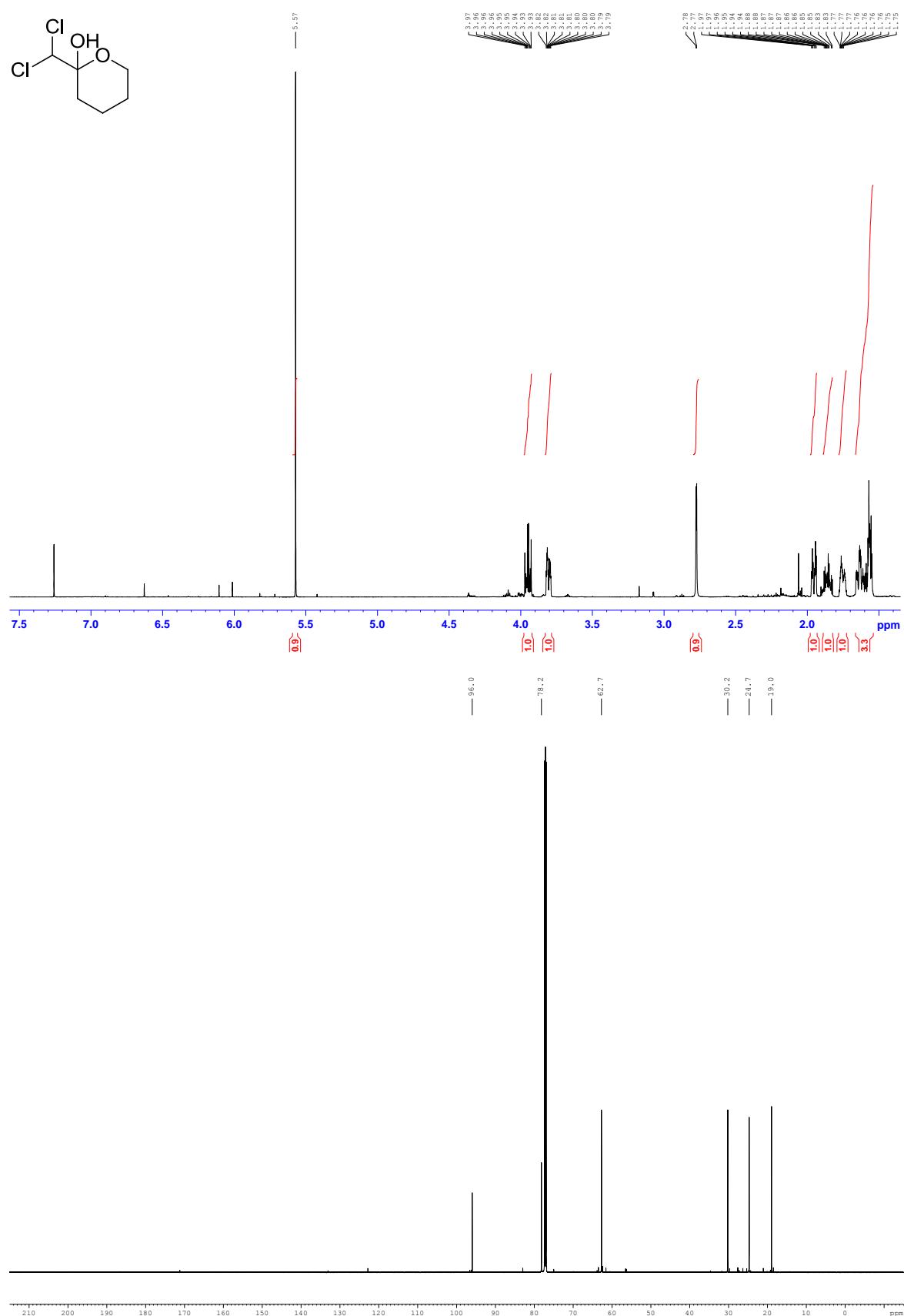
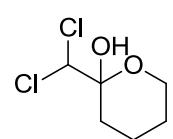
### 3,3-dichloro-2-(*p*-tolyl)tetrahydro-2*H*-pyran-2-ol (6e)



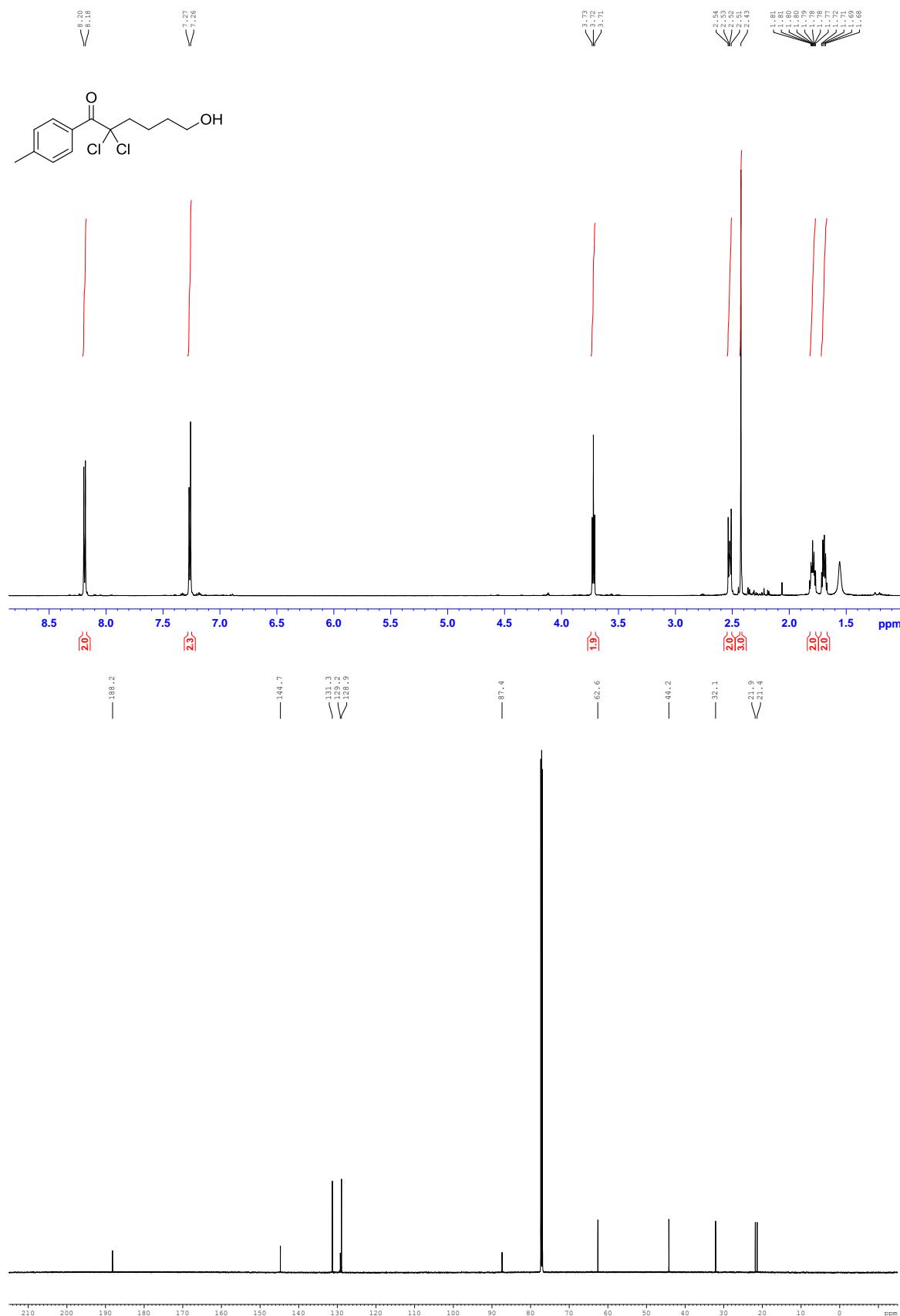
### Dichloro-2-(*p*-tolyl)tetrahydro-2*H*-pyran-2,4-diol (**6f**)



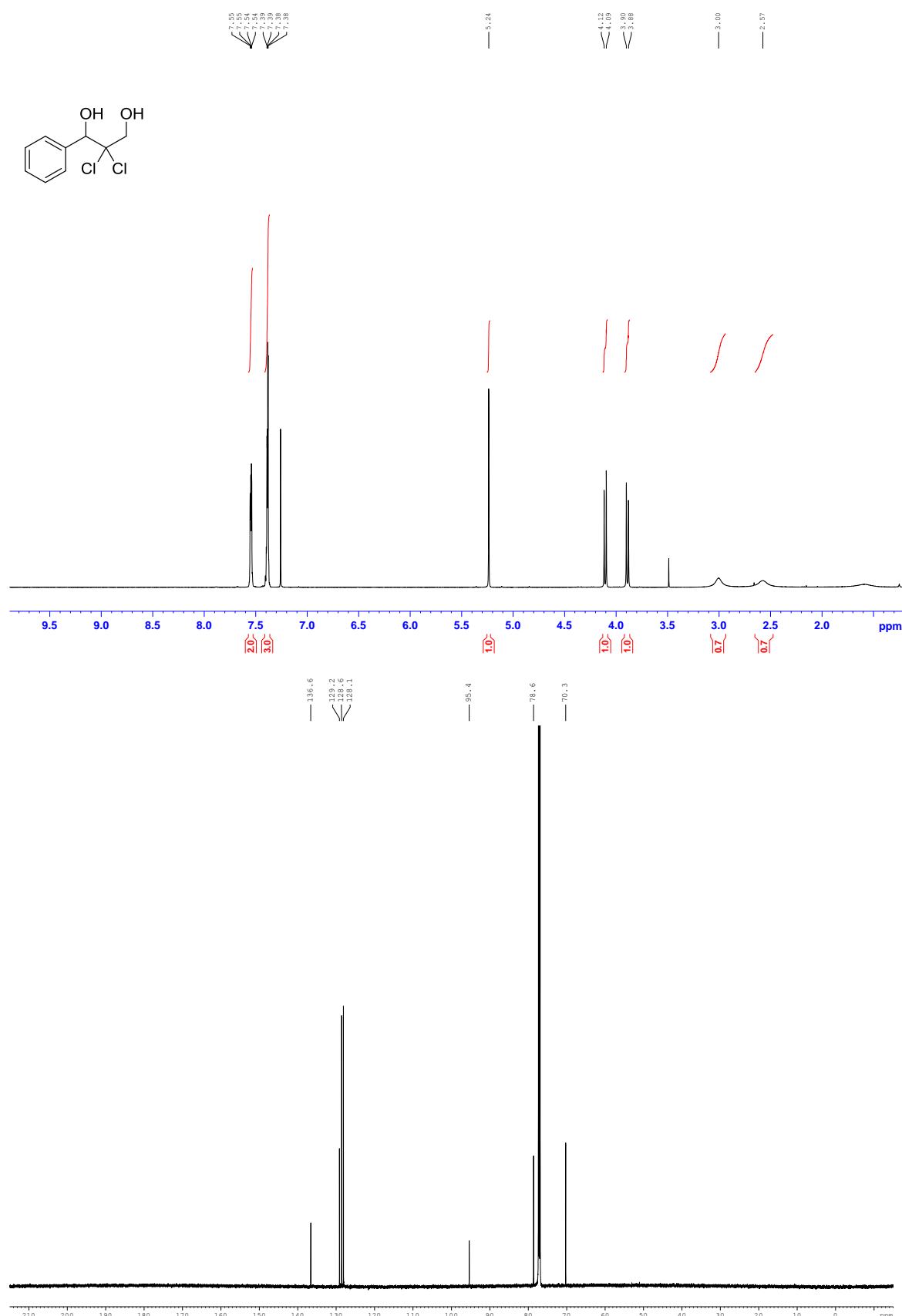
### 2-(Dichloromethyl)tetrahydro-2H-pyran-2-ol (6g)



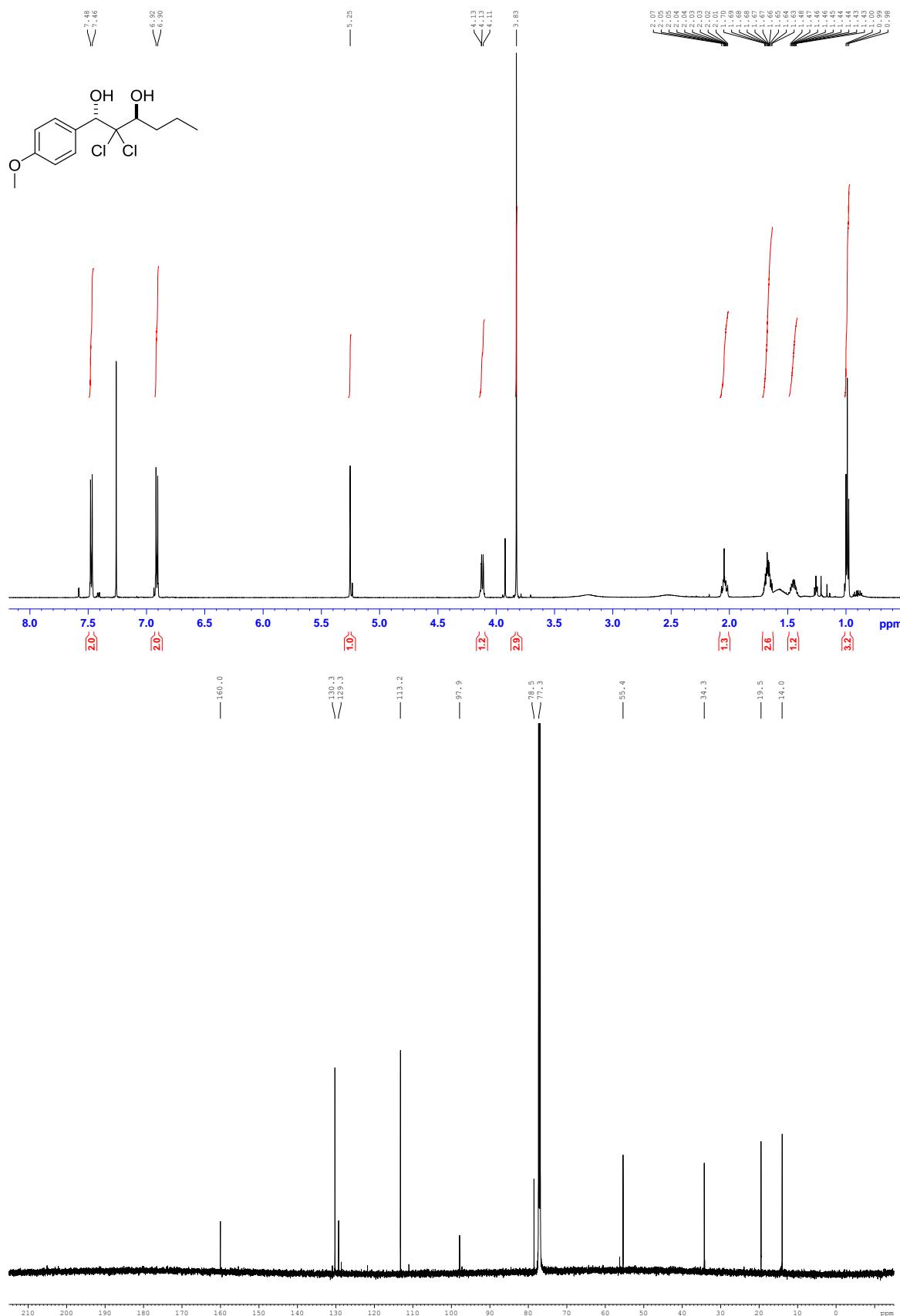
**2,2-dichloro-6-hydroxy-1-(p-tolyl)hexan-1-one (6h)**



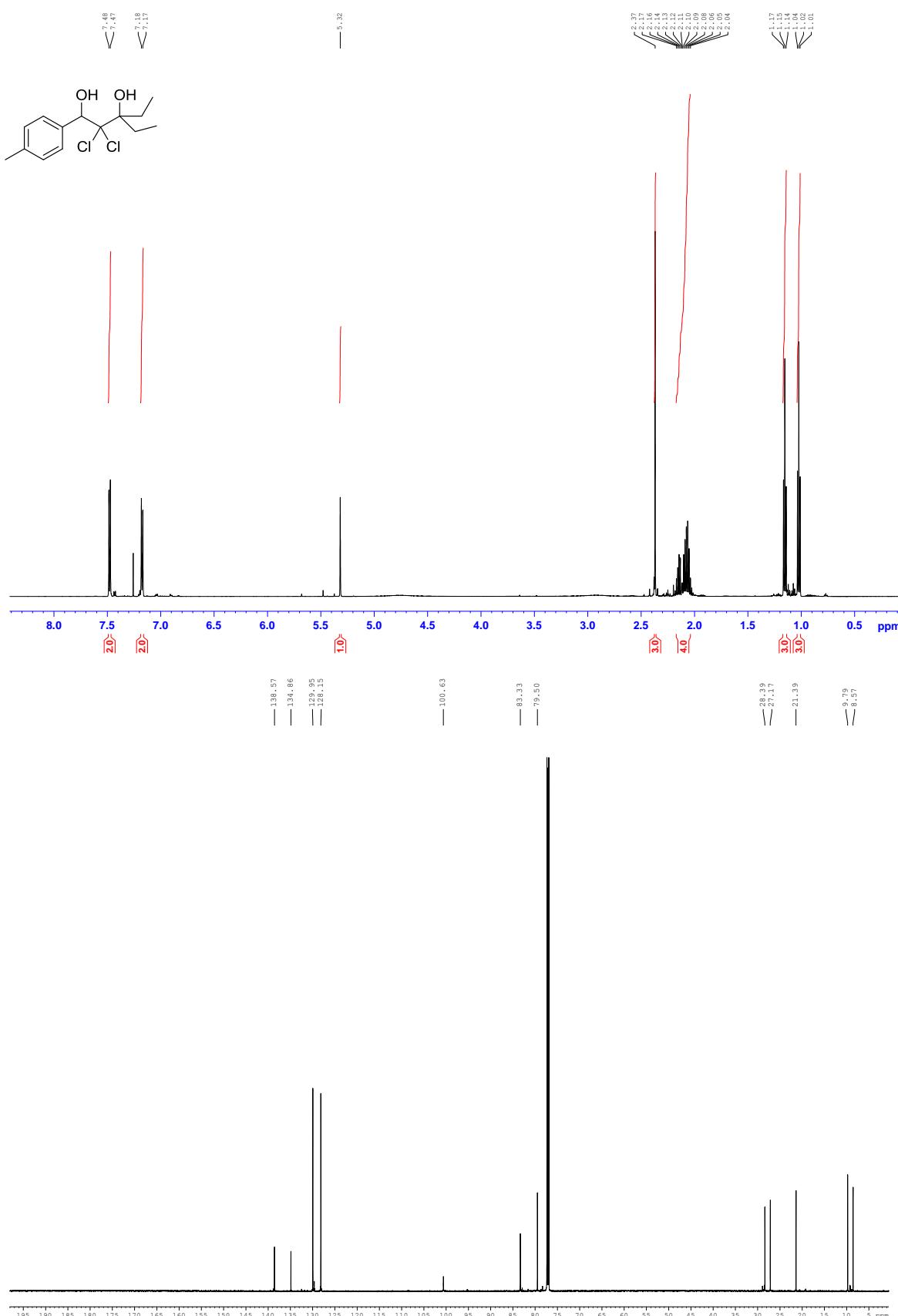
**2,2-Dichloro-1-phenylpropane-1,3-diol (7c)**



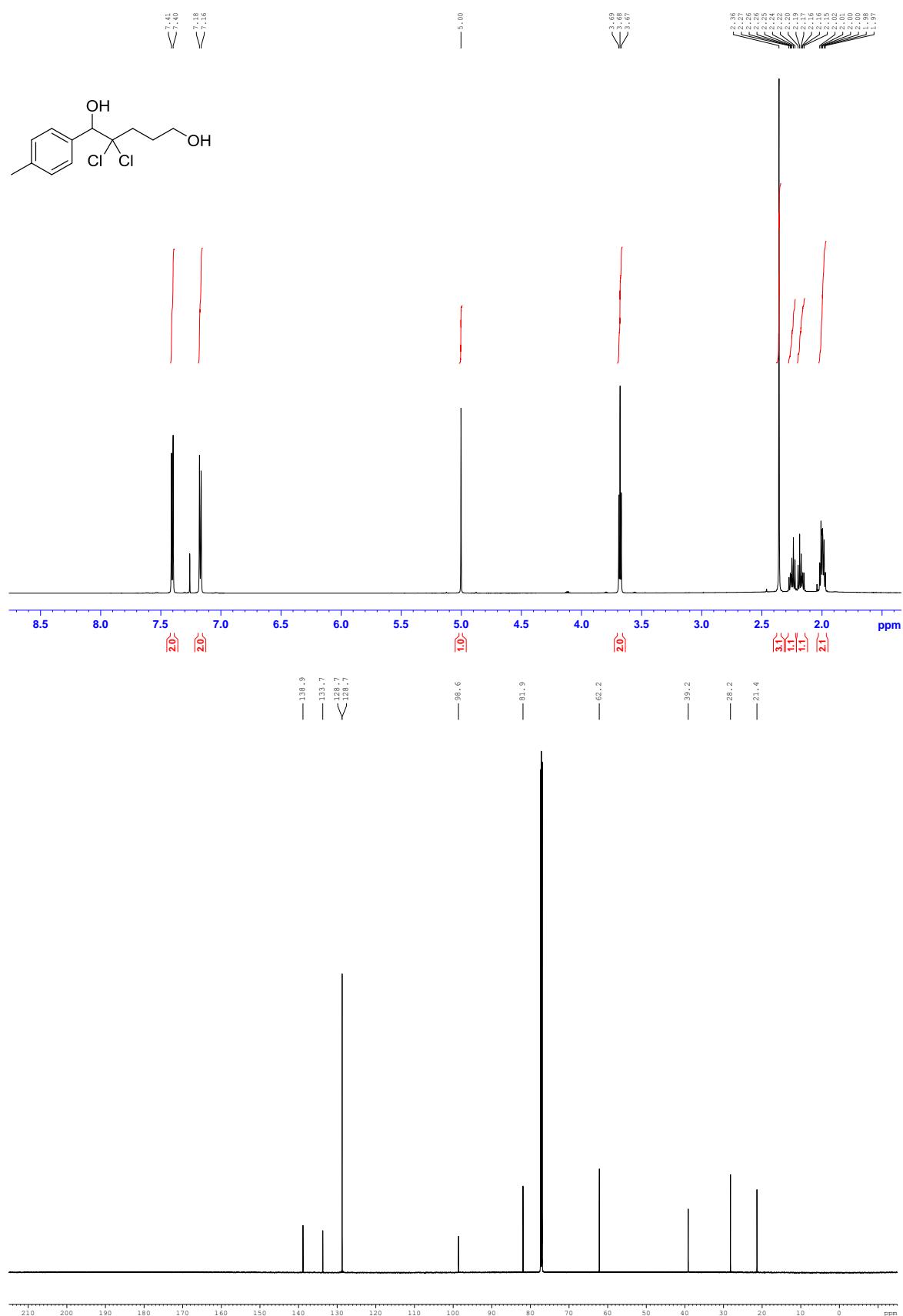
**(1*S*,3*S*)-2,2-Dichloro-1-(4-methoxyphenyl)hexane-1,3-diol (*anti*-7e)**



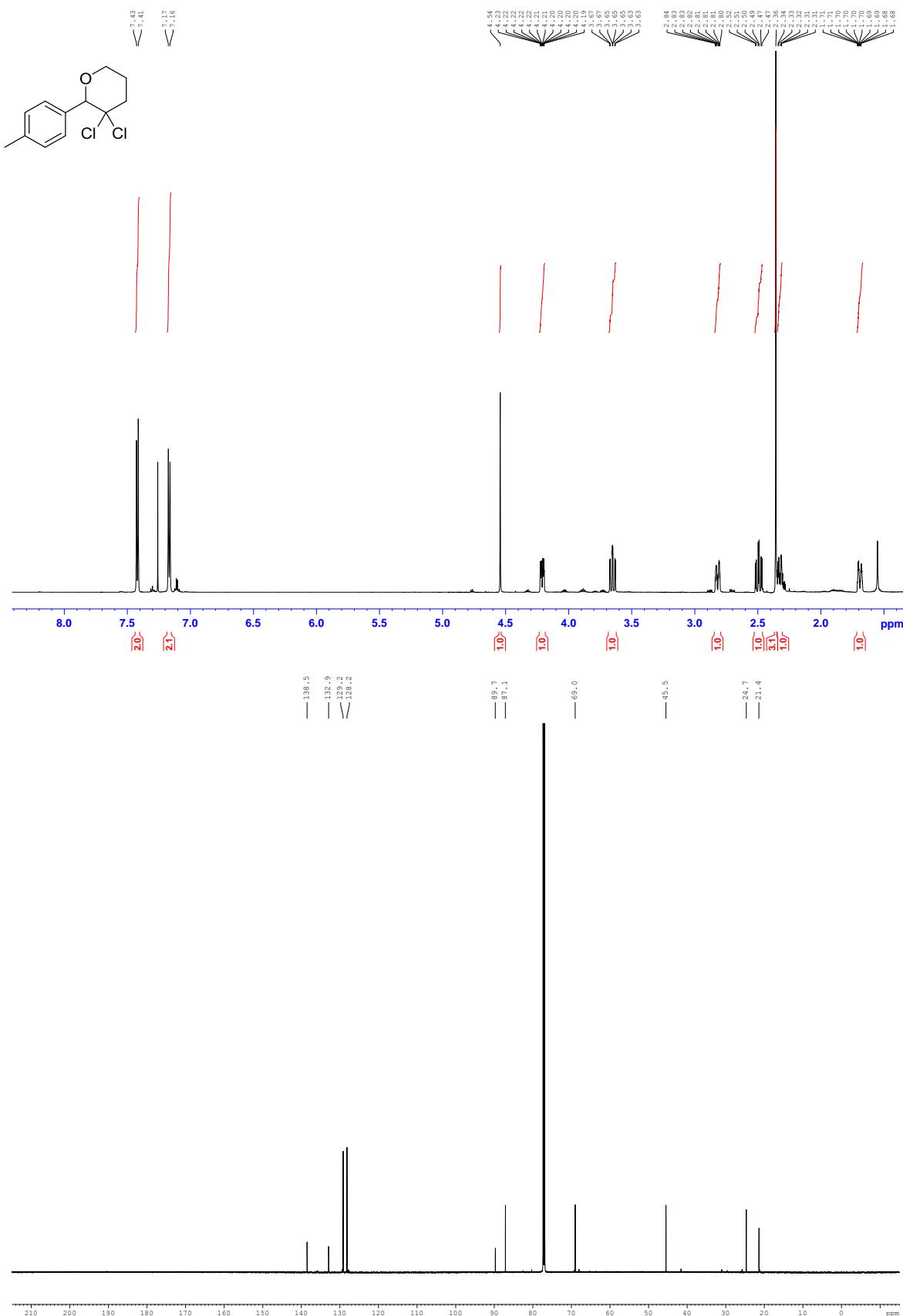
**2,2-Dichloro-3-ethyl-1-(p-tolyl)pentane-1,3-diol (7k)**



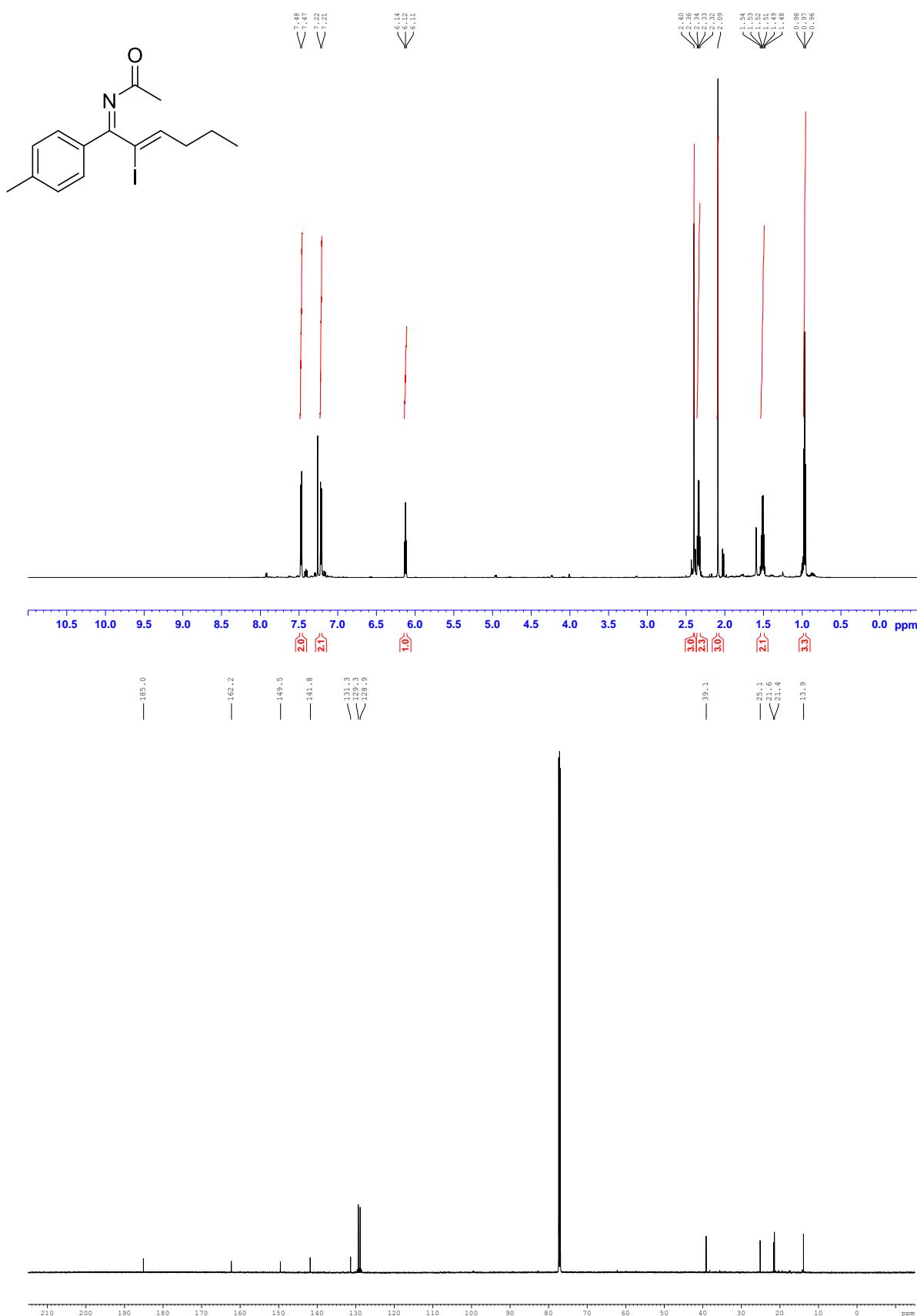
### **2,2-Dichloro-1-(p-tolyl)pentane-1,5-diol (8)**

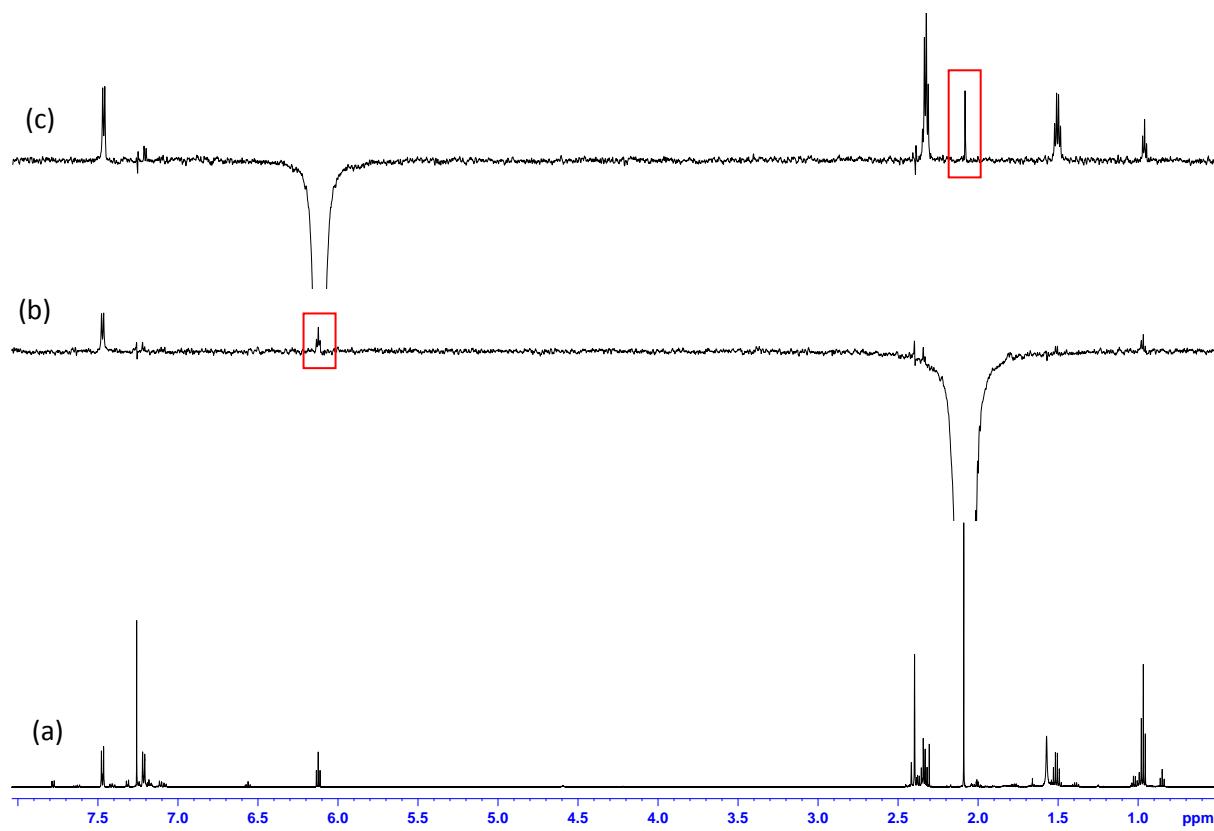


### **3,3-Dichloro-2-(*p*-tolyl)tetrahydro-2*H*-pyran (9)**

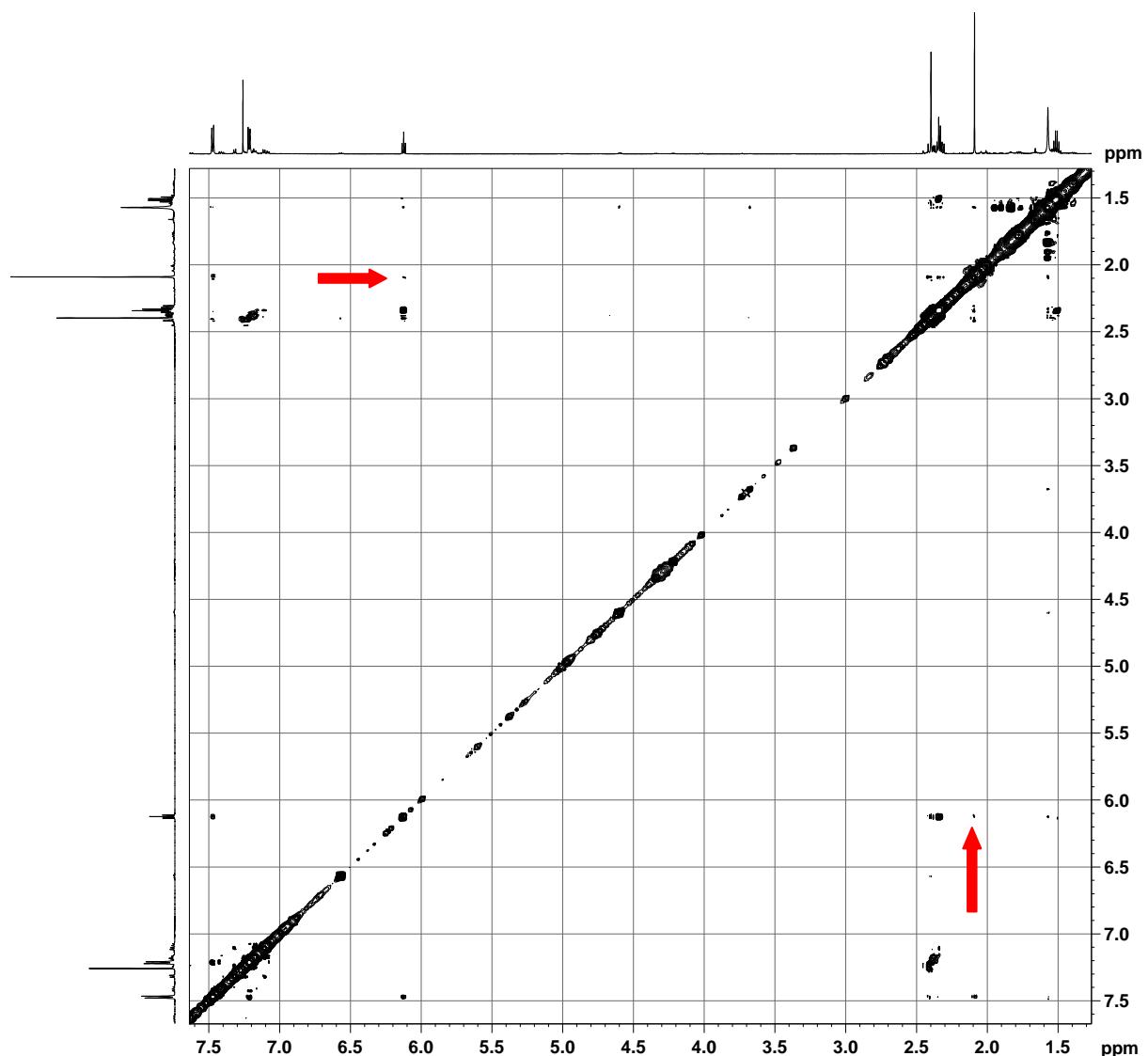


**N-((1Z,2Z)-2-Iodo-1-(p-tolyl)hex-2-en-1-ylidene)acetamide (10)**

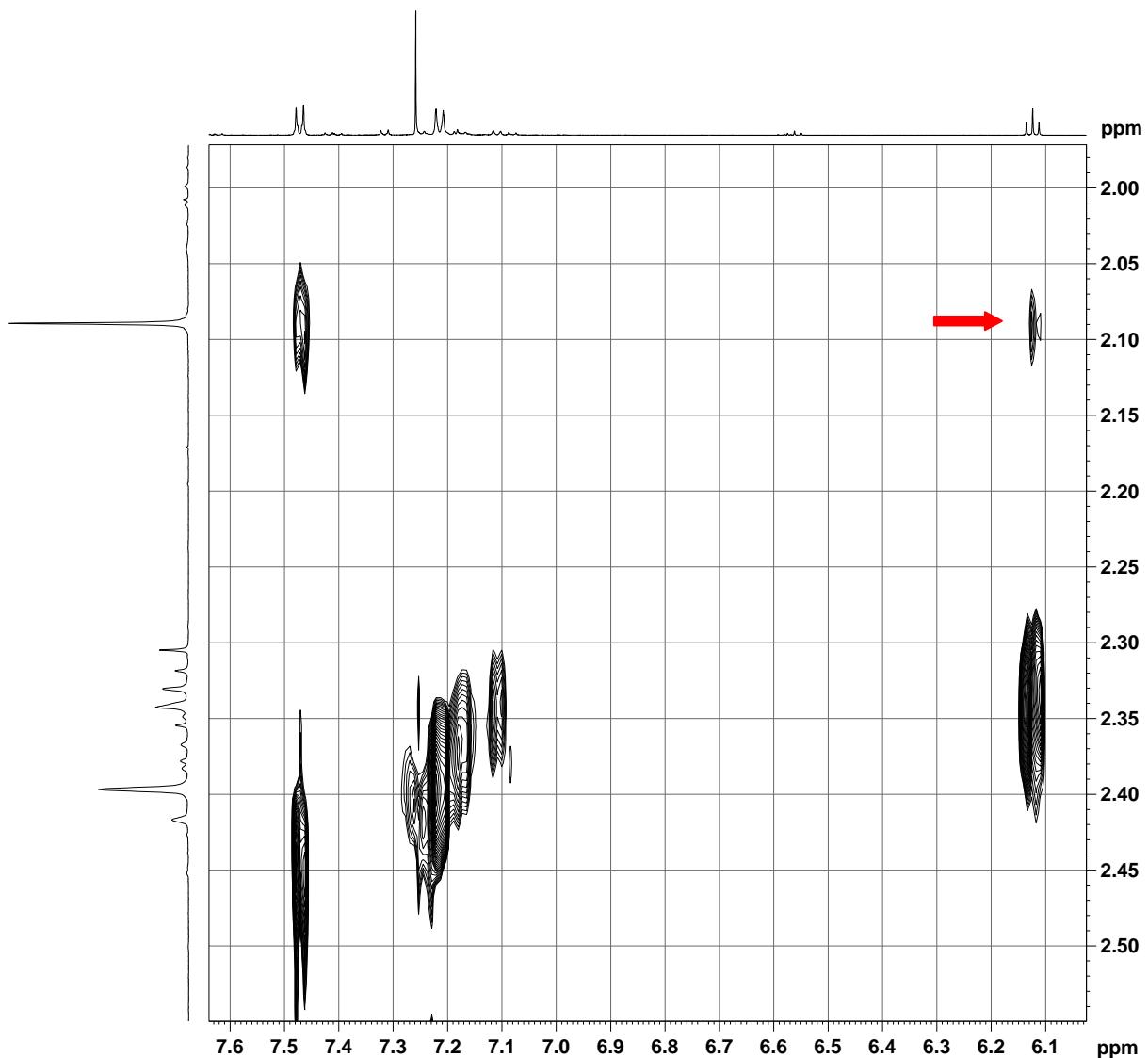




**Figure S1.** (a)  $^1\text{H}$  NMR spectrum of **10** in  $\text{CDCl}_3$  at 298 K (600 MHz); (b) 1D NOESY spectrum of **10** with selective excitation of methyl protons of  $\text{COCH}_3$  at 2.09 ppm; (c) 1D NOESY spectrum of **10** with selective excitation of the olefinic proton at 6.12 ppm. NOEs between protons  $\text{COCH}_3$  and  $=\text{CHCH}_2$  are highlighted using red squares.

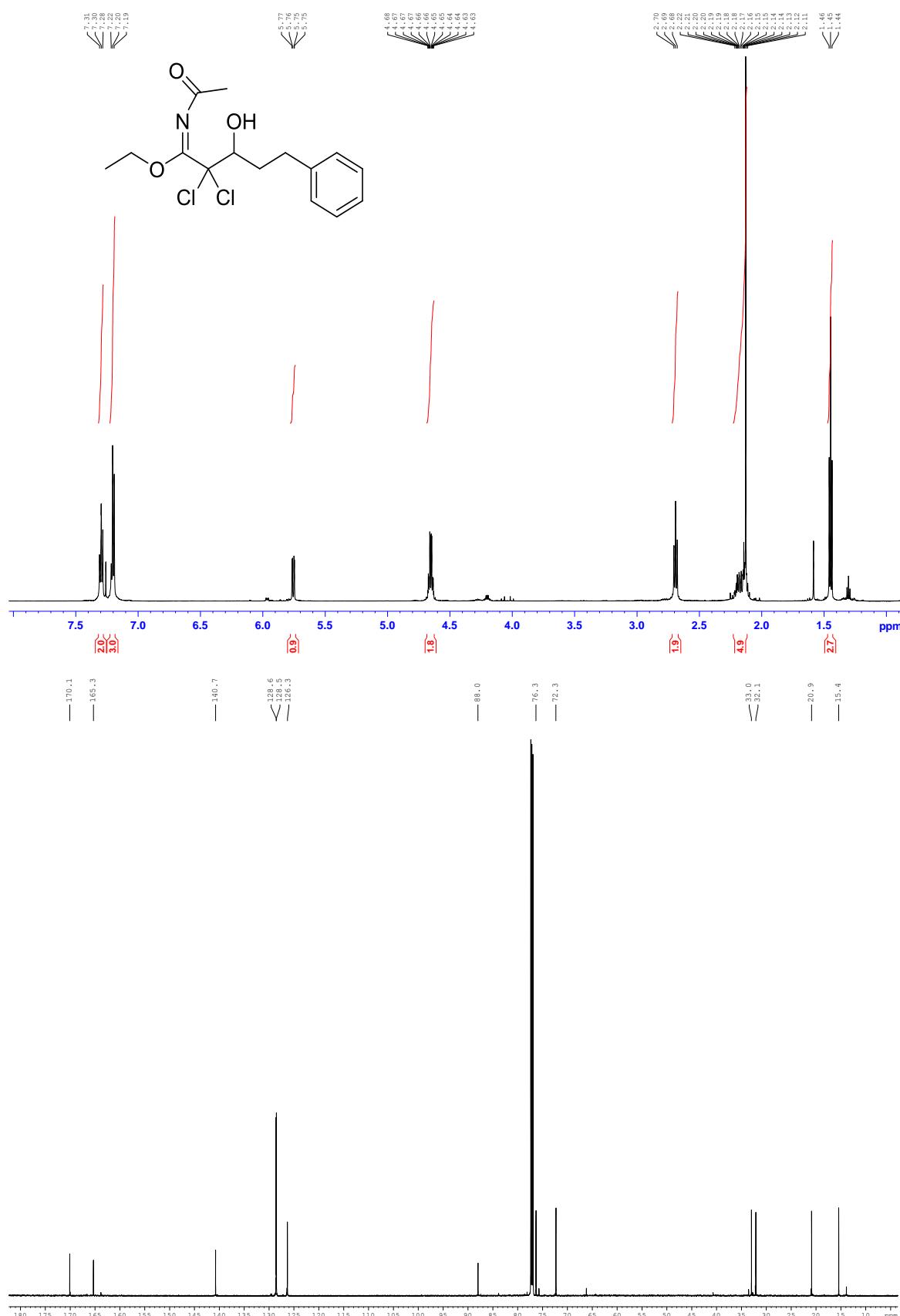


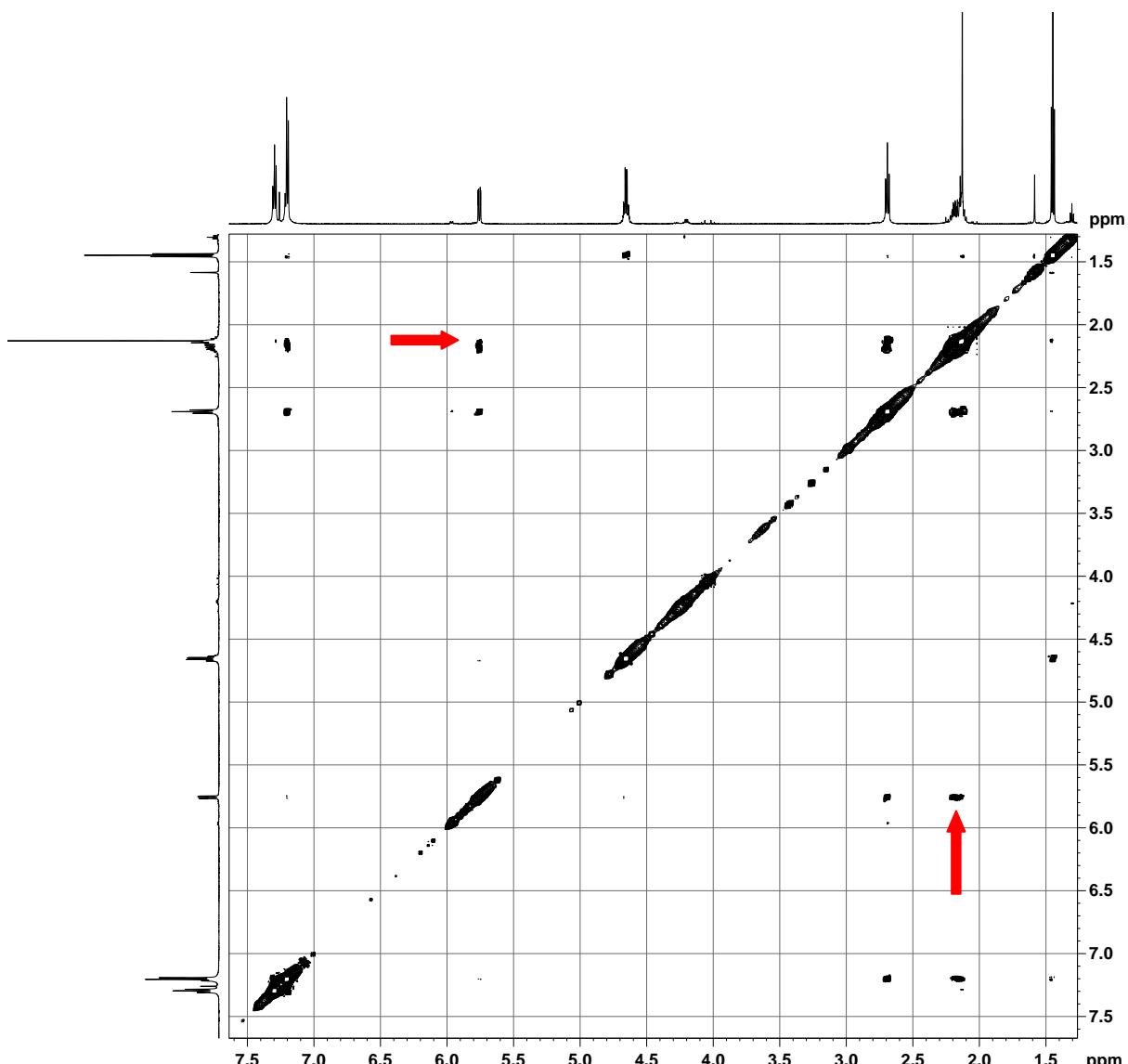
**Figure S2.** 2D NOESY spectrum of **10** in  $\text{CDCl}_3$  at 298 K (600 MHz). Cross-peaks between methyl protons of  $\text{COCH}_3$  and the olefinic proton of  $=\text{CHCH}_2$  are indicated using red arrows. Expanded view of the region of interest is shown in Figure S3.



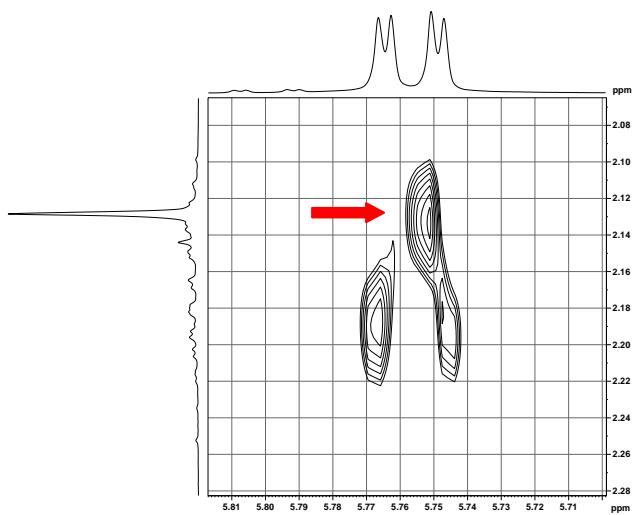
**Figure S5.** Expanded view of the region of interest in 2D NOESY spectrum of **10** in  $\text{CDCl}_3$  at 298 K (600 MHz). The cross-peak between methyl protons of  $\text{COCH}_3$  and the olefinic proton of  $=\text{CHCH}_2$  is indicated using a red arrow.

**(E)-N-Acetyl-2,2-dichloro-3-hydroxy-5-phenylpentanimide (11)**





**Figure S4.** 2D NOESY spectrum of **11** in  $\text{CDCl}_3$  at 298 K (600 MHz). Cross-peaks between methyl protons of  $\text{COCH}_3$  and the methine proton of  $\text{CCl}_2\text{CH}(\text{OH})$  are indicated using red arrows. Expanded view of the region of interest is shown in Figure S5.



**Figure S5.** Expanded view of the region of interest in 2D NOESY spectrum of **11** in  $\text{CDCl}_3$  at 298 K (600 MHz). The cross-peak between methyl protons of  $\text{COCH}_3$  and the methine proton of  $\text{CCl}_2\text{CH}(\text{OH})$  is indicated using a red arrow.